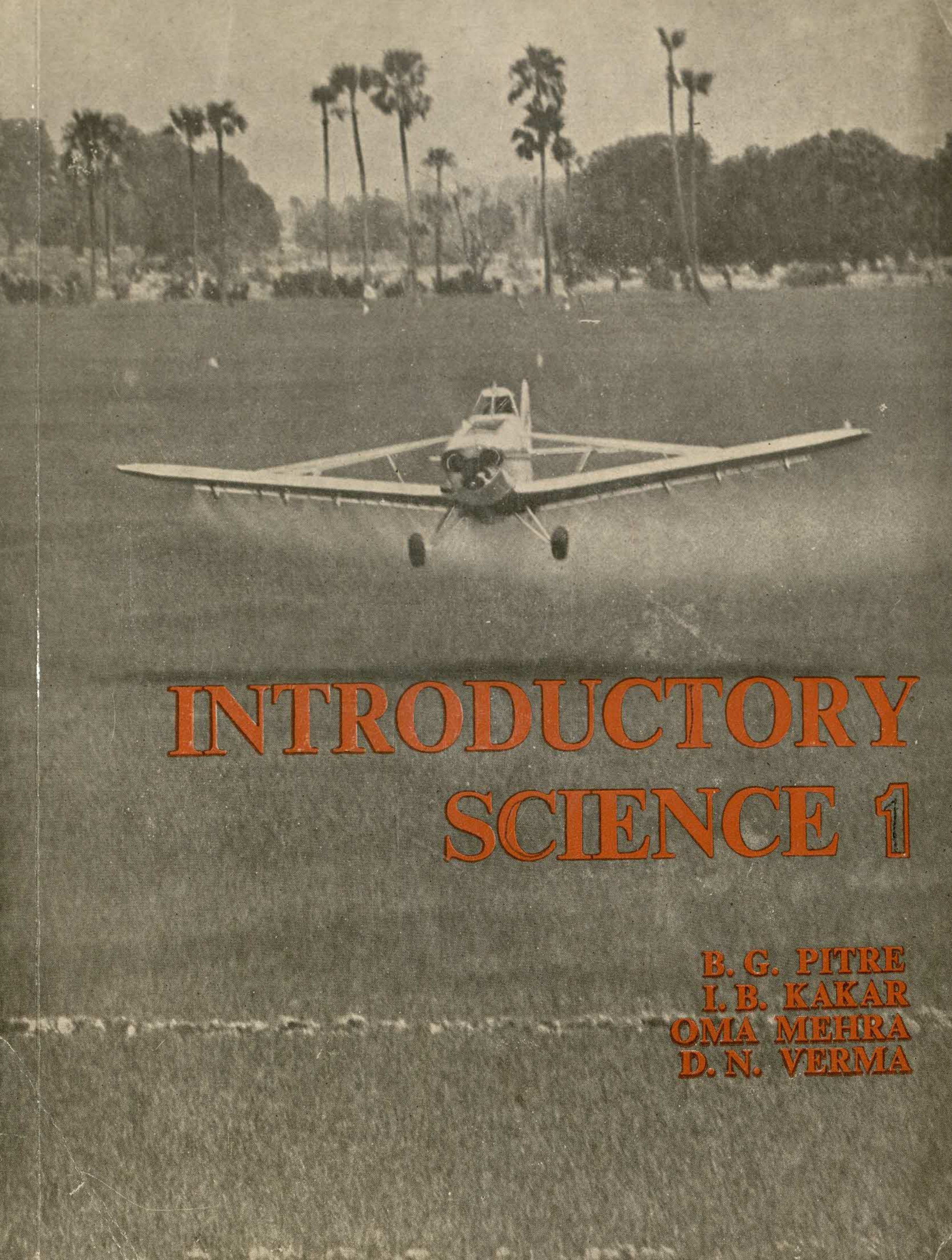

INTRODUCTORY SCIENCE 1

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A Modern Approach

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To the Teacher

In the past decade we have witnessed a number of attempts to revise curriculum and rewrite science texts for the Junior High School classes. Opinion among science educators all over the world seems to oscillate between two extreme positions—an integrated, thematic approach which most teachers find insufficiently equipped to teach, and a separate disciplined approach which is in vogue at present in our country.

It has been the cherished dream of all science educators to concieve a unified science curriculum which enables students to appreciate science as a human endeavour influeucing our society, culture and daily life, and to implement it in an integrated fashion providing glimpses of skills, techniques and concepts which form the very core of all scientific activity. Several attempts have been directed to develop new materials on the assumption that the syllabus prescribed by various educational Boards will fall in line, and that the introduction of these texts and kits in schools would significantly improve the teaching of science.

One does not need a second opinion to be convinced that the availability of new materials has had little qualitative impact on actual classroom teaching. Many reasons have been given for this state of affairs. Nevertheless, it can be safely assumed that besides a syllabus and the examination system, the texts and the teachers who use them in their classes form the vital links between a dream and its realisation.

The authors have written these texts based on their wide and deep experience in teaching and working in collaboration on several approaches to science teaching. These texts in three volumes cover approximately the three-year course in science at the middle school stage in English medium schools. The authors hope that the texts will commend themselves in providing sufficient knowledge for an intelligent appreciation of the modern progress in science, while creating a broad unified background and a strong foundation to serve as a preparatory course for the three specialised disciplines at the secondary stage.

In offering these texts to the pupils, the following considerations have weighed upon our minds :

(*a*) Theory should be sufficiently interspersed with practical activity in the development of a topic. Many experiments and demonstrations have therefore been suggested so that students may be guided to conclude and form concepts based on the observation and interpretation of the experiments.

(*b*) Lengthy explanations, unnecessary mathematical derivations and irrelevant taxonomical details should be avoided in a first-acquaintance presentation to science. Problems, both theoretical and numerical, have therefore been included with an aim to show further applications of the principles rather than to engage pupils in repetitive work.

(*c*) Next to a first hand experience of apparatus and phenomena, clear illustrative diagrams and photographs are the best aids to a proper assimilation of the subject, and of its extension to technology and environment in the out-of-school world. No time and effort has been spared to equip the text with illustrations.

Concept development in students is a gradual, cumulative process; the sequence of topics should therefore be psychological rather than logical. The unconventional presentation of course content in these texts enables a lot of good science to be taught in an economical and efficient way. It has been successfully trial-tested for several years by the authors and their colleagues, yet it gives the teacher a relatively free choice to select his own sequence.

The authors realise that there is no unique way to teach a subject. Moreover, a first attempt to present it in a book form lacks refinement. It would therefore be appreciated if they receive critical comments and suggestions from teachers who actually use the texts in their classrooms.

May 24, 1975

B.G. PITRE
General Editor

1

The World of Science

The world around us is always changing. Early man was concerned mainly with his survival and day-to-day problems. Each morning brought him the welcome rays of light and warmth from the sun. He satisfied his hunger by hunting other animals and eating their raw meat. He was himself in constant danger of being attacked by bigger animals. Living in groups and the use of implements gave him some protection and safety. The discovery of fire, the art of building shelters and the science of growing crops were gradual stages which helped him to settle down and make their life comfortable. The earliest scientists were the men who made this possible. The method of exploring nature to understand its patterns and changes was the earliest science.

EXPLORING NATURE

We have only to look around us to realise how the work of scientists has influenced us. This book you are reading requires ink, paper and letter types which are all made in factories and may have reached the printing press hundreds of kilometres away. The ball point pen you use, the zip on your trousers, the transistors at home and a number of medicines have become common only in the last decade since you were born.

The feeling of wonder and an urge to explore is present in all of us. Have you not enjoyed the sight of a rainbow or the fragrance of flowers during the spring? Do you not watch with curiosity the flight of an eagle or the running engine of a car or train? Did you not dream of going on a long voyage to distant lands or of climbing to the top of high mountains? The urge to explore nature and accept challenges, with the confidence gained through proper training, leads scientists to seek explanation of natural phenomena and to invent new materials and gadgets.

TOOLS FOR EXPLORATION

Scientists constantly employ simple pieces of apparatus such as a thermometer, microscope, balance, etc. to explore nature. They give better and more accurate information about happenings in nature than what our senses can directly obtain. We shall often use such apparatus in our activities throughout this course of study.

Mathematics is a technique very essential to help us understand natural phenomena; this also involves measurements for obtaining reliable information, The three basic measurements are length, mass and time. The basic unit of length is a ***metre***; its other related units which we use in practice are given below:

1 kilometre (km) = 1000 metres (m)
1 metre (m) = 100 centimetres (cm)
1 centimetre (cm) = 10 millimetres (mm)

Diagram 1 shows the sizes of various objects and the use of these units of length to give an idea of how big or small the objects are.

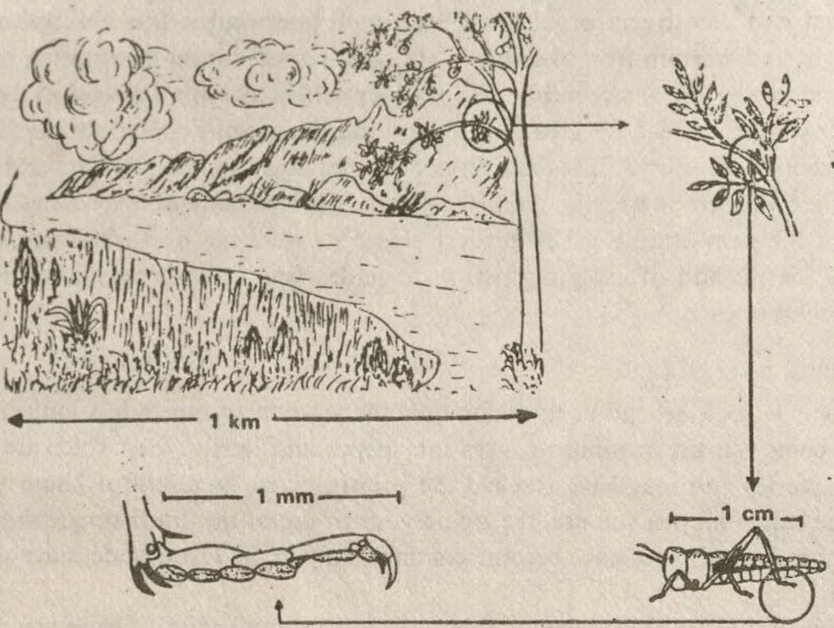


Diagram 1

THE SCIENTIFIC METHOD

Perhaps the most important tool of a scientist is his method—the way he approaches a problem to solve it. While he studies such phenomena, he gathers more information through experiments and careful observation to enable him to obtain a clear idea of the phenomena. Let us try this method ourselves.

A ***Bunsen Burner*** is the most common source of heat in science laboratories. A gas enters the tube T (diagram 2) through a jet J while air enters through an air hole H. Let us study the working of this burner by carrying out the following experiments.

Activity 1. Close the air hole, turn the gas full on and light it with a match stick, Note the size and colour of the flame. Hold a piece of broken porcelain with a ***pair of tongs*** in the flame. What do you notice on the porcelain?

Now slowly open the air hole and note the colour of the flame. Again hold a piece of porcelain in the flame. What do you notice?

You will observe that when the air hole is closed the porcelain is coated with soot. The flame is yellow and smoky. It gives out light and is therefore called a ***luminous*** flame. When the air hole is open, the flame gives little light and is called ***non-luminous***; the flame is ***non-smoky*** as no soot deposits on the porcelain.

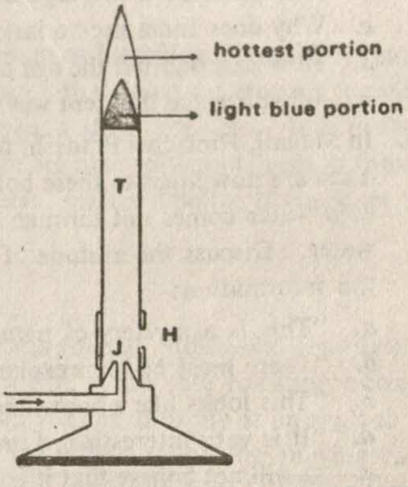


Diagram 2

Activity 2. Now hold for a short time a wooden splint horizontally in the upper and then in the lower part of the non-luminous flame. Which part of the flame chars or burns the splint first? Close the air hole and hold the wooden splint in the luminous flame. What do you observe?

The experiment shows that the wooden splint chars quickest when held in the upper zone of the non-luminous flame; this is the hotter part of the flame. You would also observe that the size of the flame depends upon the amount of gas, and not of air, that goes into the burner. However, the gas burns completely and gives a hotter flame when mixed with air. Thus a simple experiment with a systematic and careful study could provide us a lot of information.

Several Indian scientists have made important contributions in increasing our understanding of the world. Jagadish Chandra Bose, Satyendra Nath Bose, Homi Bhabha, Prafulla Chandra Ray, Vikram Sarabhai, Satish Dhawan, Birbal Sahni, Homi Sethna and M.S. Swaminathan have earned world fame. C.V. Raman was awarded the Nobel Prize in Physics for discovering a peculiar way that light behaves, known as the **Raman Effect**. The Indian-born Har Gobind Khorana was awarded Nobel Prize for his work on the ***Genetic Code***.

PROBLEMS

1. What are the good and harmful changes in the world brought about by the advancement of science in the past 25 years? What is your solution to stop the harmful effects?

2. What does each of the following scientists do: A meteorologist, geologist, chemist, botanist, zoologist, an astronomer, ornithologist?
3. Gather information from books and magazines to answer adequately two of the following questions:
   - *a.* Will man ever stay permanently on the moon?
   - *b.* Will there be a shortage of food and water in the future?
   - *c.* Why does India need a large number of first rate scientists?
   - *d.* How can one tell the age of the earth?
   - *e.* What are the different ways of obtaining and storing information?
4. In Manali, Himachal Pradesh, there is a rock with two holes about 1 metre apart. Taps are now fitted to these holes through which water runs out. Surprisingly, cold water comes out through one of them while the other gives out very hot water. Discuss the attitude of five persons who said the following when given the information:
   - *a.* "This is a mystery of nature which science can never solve."
   - *b.* "There must be some explanation but I cannot give it myself."
   - *c.* "This looks like a hoax; someone is playing a joke."
   - *d.* "It is very interesting; I must visit the place."
   - *e.* "I will not believe that it is true until I know a cause for this."

A NOTE OF CAUTION

In order that the laboratory work runs smoothly, you have to take some precautions:

In case of accident, inform your teacher immediately.

To avoid mishaps, check labels before using chemicals.

Never taste chemicals or eat in the laboratory.

After you have used an apparatus or a chemical, place it back in its correct position.

If any chemical falls on to your hand, wash with plenty of water.

If you have to smell a gas, do it cautiously.

Inspect an apparatus for cracks or faults before use, and obey the instructions for its use carefully.

Do not carry out any other experiments without the permission of your teacher.

Record your observations as soon as you have made them.

After you have finished an experiment, leave bench tops and the apparatus clean and tidy.

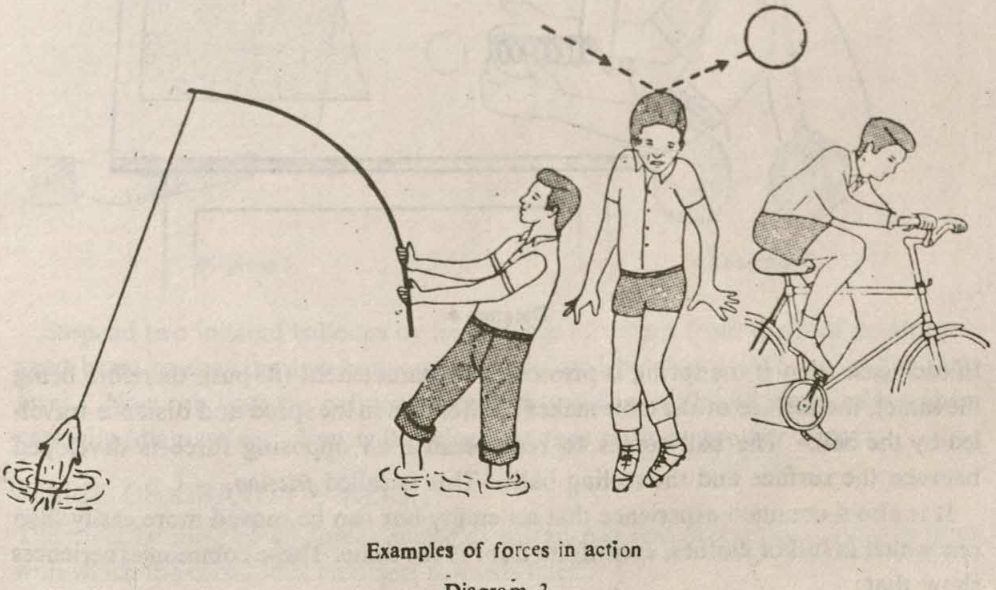
2

Forces in Nature

The use of force in our daily life is just as common as breathing. We freely make use of forces to kick a football, to lift a glass of water, to walk on the ground, to catch or throw a cricket ball, to ride a bicycle, to open a door, etc. etc. It is in fact impossible to live without applying force. There are many different types of forces but most of them can easily be put under two sets: **push** and **pull.** If you want to move a lawn mower you either push or pull it.

PUSH AND PULL

Activity 1. Push a ball along a floor and it starts rolling. Hold your hand firmly in the path of a rolling ball and it could stop; actually, in this case you apply a force in the opposite direction to its motion. Now hold your hand firmly at an angle to a moving ball in its path. You will notice that the direction of the moving ball changes. All these actions are often employed while playing cricket; to stop or catch a ball, or while driving a ball with a bat, you apply an opposing or inclined force.



Examples of forces in action

Diagram 3

Activity 2. Hold a spring in your hand and pull it; it extends in length. Push the spring from both ends and it gets compressed in length. Hold an eraser in your hand and twist it; the eraser gets deformed in shape.

We observe that the push or pull may have several different effects: *a force moves an object from rest or makes an object move faster or slower or changes the direction of a moving object, or changes the size or shape of the object.*

FRICTION

If you push a ball, it rolls forward. However, it gradually slows down and comes to rest even if you do not stop it. Is there any other force responsible for this?

Activity 3. Arrange a stiff spring to be held firmly horizontally at one end of a long table. Now press a hockey or cricket ball against the free end of the spring and release it. The ball is pushed away by the spring. Now make the top surface of the table different by spreading a lot of sand on it and repeat the experiment (diagram 4). You will notice that the ball bogs down in the sand and comes to rest quickly. You may repeat the experiment making the surface very smooth by placing a long glass plate on it.

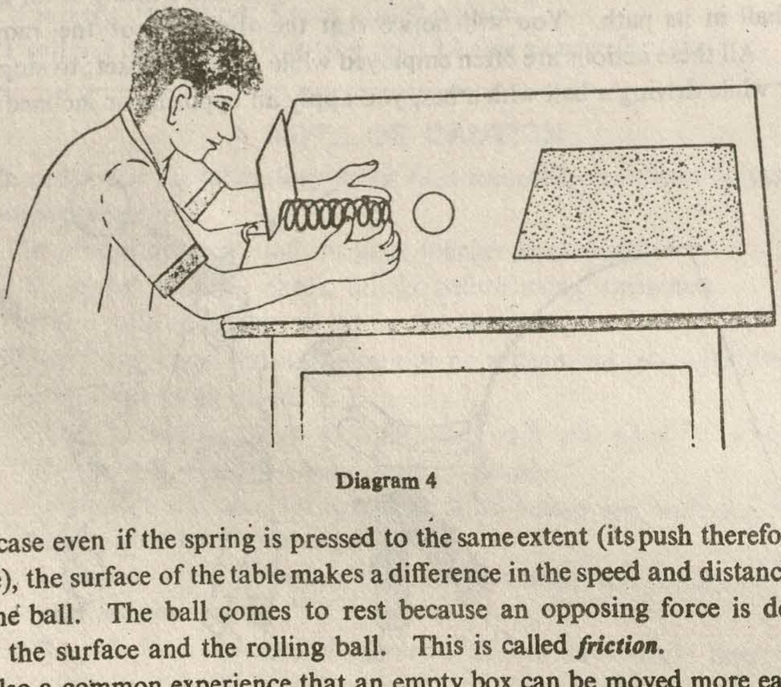


Diagram 4

In each case even if the spring is pressed to the same extent (its push therefore being the same), the surface of the table makes a difference in the speed and distance travelled by the ball. The ball comes to rest because an opposing force is developed between the surface and the rolling ball. This is called ***friction.***

It is also a common experience that an empty box can be moved more easily than one which is full of clothes, even if the floor is the same. These common experiences show that:

(*a*) when an object moves over another, there exists a force which opposes the motion, and it is called friction.
(*b*) friction increases with roughness of the two surfaces in contact.
(*c*) friction increases with weight of the object when surfaces are the same.

Parts of machinery wear out easily because of friction, and a lot of fuel is wasted in driving objects while overcoming friction. The force of friction, hence wear and tear in moving parts of machinery, is effectively reduced by applying grease or oil in them.

Friction however is a useful force in other cases. It prevents vehicles from skidding and enables us to walk without slipping. When brakes are applied to stop cars, bicycles, etc. they cause friction to be produced which opposes the motion effectively.

FORCES AT A DISTANCE

You must have played with magnets and observed how nails and paper pins stick to a magnet. Does this attraction act even from a distance?

Activity 4. Suspend a nail from a stand with the help of a piece of thread. Now gradually bring a magnet close to it (diagram 5). You will notice that the nail gets pulled towards the magnet even when the two are not in contact.

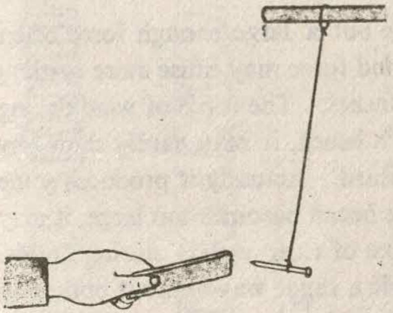


Diagram 5

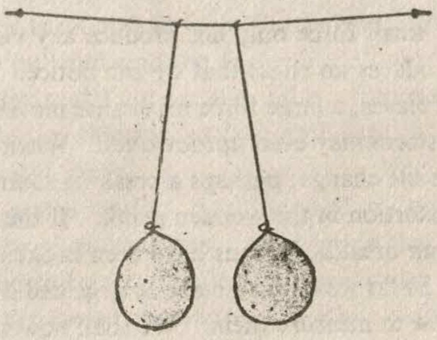


Diagram 6

Suspend two inflated balloons by long pieces of thread from the roof or an overhead beam so that the two balloons are separated by about 10-15 cm at the same level. Now rub both the balloons against a woollen cloth and again release them carefully (diagram 6). You will notice that they push each other away.

FORCE OF GRAVITY : WEIGHT

The most familiar of all forces acting at distance is that of gravity. It is the force with which the earth pulls an object towards itself.

Activity 5. Hold your hand stretched horizontally and ask someone to place a brick on your open palm. Do you feel the force of gravity on the brick pushing your hand downwards?

Everyone on the earth, and every object that we see, experiences the force of gravity. It is such an important force which we always have to reckon with that we give it a special name: ***weight***. *The weight of an object is a force by which the earth pulls it towards itself.* This force therefore always acts downwards.

The weight of an object is not the same at every place on and around the earth. Just as in the case of magnets and balloons in an earlier experiment, this force becomes weak with increase of distance as the object is removed away from the earth. When we lift a brick, we apply a force upwards against the pull of gravity. When a magnet lifts a nail from the ground, its magnetic pull is more effective than the downward pull of gravity. In fact, under certain conditions the weight of an object (the downward pull by the earth) can be made zero; the object is then said to be ***weightless***.

On the moon the pull on an object is due to moon. The moon is much smaller than the earth; any scientific instrument, or an astronaut, will therefore weigh much less on the moon than on the earth.

LARGE AND SMALL FORCES

A small force may not produce any visible change but a large enough force often produces an effect that we can notice. A small wind force may cause mere rustling of leaves; a large force may cause movement of branches. The force of wind during a storm may even uproot trees. When you sit on a bench, it may hardly show any visible change; perhaps a creaking sound may be heard. Actually it produces some distortion in the wooden plank. If the load on the bench becomes too large, it may even break. Bridges have been broken by the force of river waters during floods.

So far we discussed about large and small forces in a vague way without bothering how to measure them. We shall now see how we could measure them. Forces are measured in comparison with standard forces. *The force with which the earth pulls a mass of 1 kg towards itself is called 1 kilogram-force or 1 kg-f. About one-tenth of this force is named 1 newton.* Hence,

$$1 \text{ kg-f} = 10 \text{ N}$$

Activity 6. Hold a kilogram mass in your hand. You are now feeling a force of 1 kg-f. If you keep a 100 g mass on your palm, you will feel a force which is very nearly equal to 1 newton. If you hold a 1 g mass in your hand, you will feel a very tiny force which is called 1 g-f or 1 gram-force.

One of the simple instruments used to measure forces is the ***spring balance***. In your earlier experiment with a spring you will have noticed that if you hang two equal loads from a spring the extension in the spring is twice as much as produced by a single load; and three times the force will produce an extension three times. When the loads are removed, the spring returns to its original length. This serves as a simple basis for constructing a spring balance to measure forces.

To construct a spring balance, standard weights are hung from a spring and the extension recorded on a scale with the help of a pointer (diagram 8). The scale is thus ***calibrated***; an unknown load can be measured by hanging it from the spring and reading the force shown by the pointer.

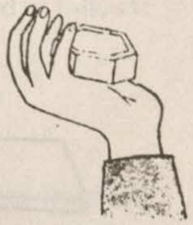


Diagram 7

Activity 7. Take a spring balance and read the maximum load it can measure. Also calculate the force which makes the spring extend through one division on the scale. The smallest force it can measure is called its least count; it tells us how sensitive the spring balance is to small changes in forces. Now hang an unknown weight and read how much it weighs. Attach the hook of the balance to a door handle of a closed door, and pull. Read how much force is needed to pull the door open. Tie a string round a thick book and fix it to the balance; gently increase the pull and read the force needed when the book just starts sliding on the table. Repeat the experiment on a different surface and explain why there is any difference.

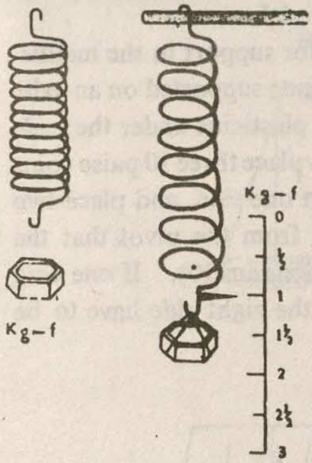


Diagram 8

We have stated earlier that the pull of gravity changes from place to place. It suggests that the extension shown by a spring due to a particular load will not be the same everywhere. In other words, it would appear that a weight of 1 Kg-f will show different readings at different places on the earth, in mines and on mountain tops. However, the ordinary spring balances we use do not show the small difference at all, although apparatus with greater sensitivity can show this difference.

TURNING FORCES

Forces are used not only to change motion of objects or distort their shapes, but also to twist and rotate them round. In such cases it becomes important to consider where the force is applied.

Activity 8. Open a door by applying a push near the handle. Now find out whether the force needed to open the door is the same if it is pushed near the hinges. You will realise that closer to the hinges a greater force is needed.

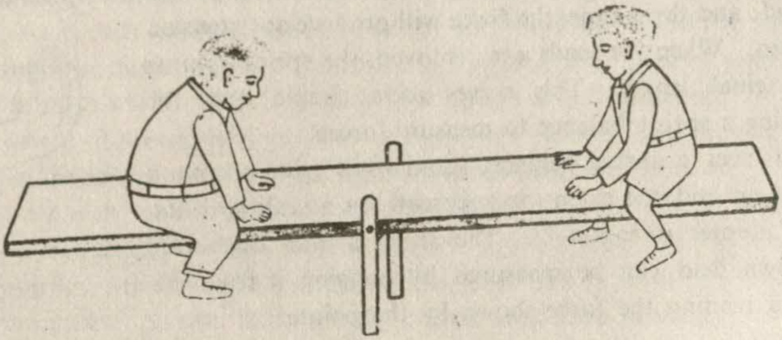


Diagram 9

You may have seen two children playing on a see-saw. If one of them is heavier, they could still balance the see-saw but one of them will have to sit closer to the centre (diagram 9). The centre of rotation is called ***fulcrum.*** Thus a smaller force can be more effective in turning object if it acts at a greater distance from the fulcrum. We can investigate this effect by setting up a model see-saw.

Activity 9. Take a 1/2 metre scale with an arrangement for support in the middle. The scale can be balanced by placing it over a narrow pivot, or supported on an axle, which acts as the fulcrum. (You can stick a small piece of plasticine under the scale at a convenient place to make the scale balance easily). Now place three 10 paise coins one on top of other at a distance of 8 cm from the pivot on one side, and place two identical 10 paise coins on the other side at such a distance from the pivot that the scale is horizontal. Measure and record the distance *d* (diagram 10). If one coin from the left side is removed, where will the two coins on the right side have to be moved so that the scale again balances? Can three coins on left side at 8 cm distance from fulcrum be balanced by one coin on the right side? At what distance away

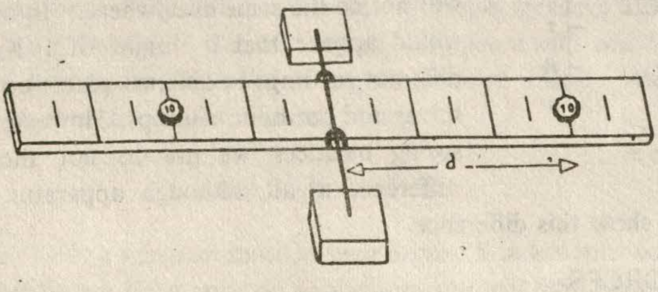


Diagram 10

from the pivot should it be placed? Try various arrangements and see if you can discover any rule for placing a small number of coins to balance a large pile on the other side.

You will find that a single coin placed far from the pivot can easily balance many coins placed near it. In fact, there exists a simple rule which can be stated as follows:

weight on one side × *its distance from fulcrum* = *weight on the other side* × *its distance from fulcrum*

BEAM BALANCE

If in the above experiment the two weights are placed at equal distances from the pivot, they must be equal if the scale is to remain balanced horizontally. A number of beam balances in daily use are based on this rule (diagram 11). For example, if

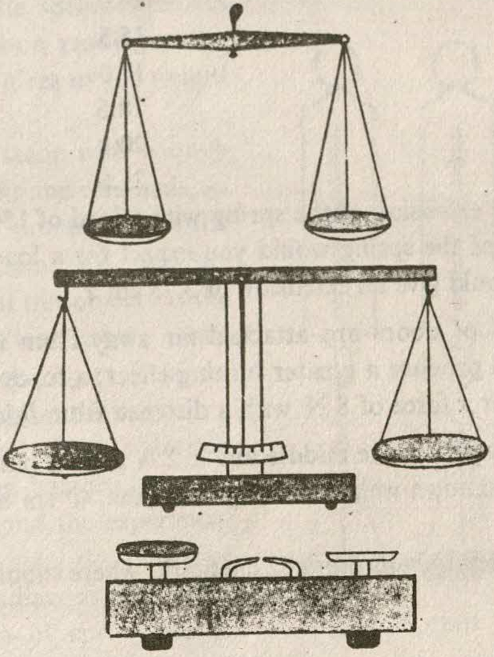


Diagram 11

a 1 kg-f weight is placed in one pan of the grocer's balance, the beam balances when any material placed in the other pan also weighs 1 kg-f. It is important to note that such beam balances must have pans at equal distances from the fulcrum. In practice the balances are not so simple in construction, and other factors, such as the weight of the beam and the pans, have also to be taken into account.

PROBLEMS

1. Name three effects of a force and give two examples of each. Name two types of forces which are given special names. Give two examples of each where they act.

2. Force of gravity of the moon on an object kept on moon's surface is much less than that of the earth if the object is on earth's surface. Yet the pull of gravity of the moon does extend up to the earth. Give one example of the action of this force on the earth.

3. In an experiment on the stretching of a spring, the following readings of the length of the spring were recorded when it was loaded:

Load (g-f)	length of spring (cm)
0	12.5
50	14.0
100	15.5
150	17.0
200	18.5
250	20.1
300	21.6

a. What was the extension of the spring with a load of 150 g-f ?

b. What length of the spring would you expect for a load of 225 g-f ?

c. What load would give an extension of 3.75 cm ?

4. Handles or knobs of doors are attached far away from the hinges. Why ? Which force would produce a greater turning effect; a force of 5 N acting from a distance of 4 m or a force of 8 N with a distance from fulcrum of 3 m?

5. A metre scale is pivoted in the middle and a 2 N load is hung from the 90 cm mark. Another unknown weight is hung from the 40 cm mark. What is the unknown weight?
If the 2 N load moved to hang from 82 cm mark, where should the other load be suspended?

3 Mass, Volume and Density

All earth-bound objects are attracted by the pull of earth's gravity. The weight of an object is a measure of the pull it experiences due to this gravity. Weight is a word in common use, but very few would have heard the word ***mass*** being used in connection with objects.

WEIGHT AND MASS

Activity 1. Set up a spring balance, to which a pan is attached. When a stone is placed on the pan, the spring stretches and the pointer shows a reading on the scale. This reading gives us the weight of the object.

Now replace the stone with enough sand, then chalk sticks and iron nails, so that in each case the pointer shows the same reading (diagram 12). We say that the weight of all the objects is the same; it does not matter what the actual weight is, nor which object is taken, as long as the reading is the same.

Let us assume that these materials, along with the spring balance, are now taken on the moon and the experiment is repeated. Would the balance show the same reading as on earth? Would the extension of spring due to the four materials be equal in all cases?

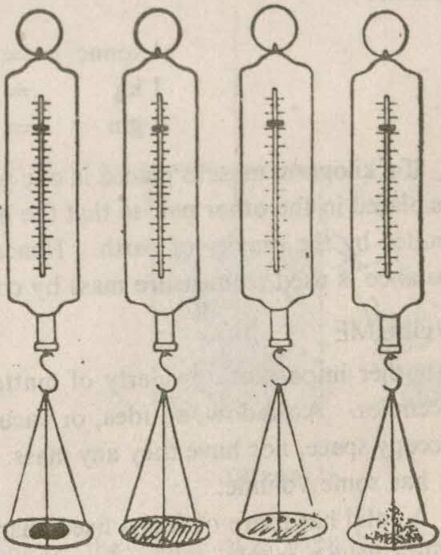


Diagram 12

Weight is a property of an object which varies. Even on earth, an object weighs less on high mountains than at sea level, although the difference would be too small to be observed by an ordinary spring balance. All the four objects would show on moon about 1/6th of their weight on earth. However, they would all show identical reading.

To explain this fact, we say that all materials are made of "stuff" or particles packed together which have a property called ***mass***. This property of mass remains unchanged wherever the object may be in universe. However the fact that an object has got some mass can be realised only when some effect due to the mass can be noticed; weight is one such property of mass of an object. This mass is therefore scientifically called ***gravitational mass***. The four materials taken all have equal mass.

Weight of an object would vary depending upon where it is placed, due to the effect of gravity of other objects on it. Mass of the object does not change. Mass is therefore a more ***fundamental*** property of matter.

MEASUREMENT OF MASS

A spring balance measures the weight of an object; it is therefore calibrated in newton or g-f units. Mass is measured in comparison with other ***standard*** masses. A standard unit of mass is a kilogram (kg). Other related units of mass are given below:

1 tonne = 1000 kilograms (kg)
1 kg = 1000 grams (gm)
1 gm = 1000 milligrams (mg)

If a kilogram mass is placed in one pan of a beam balance, and any other material is placed in the other pan so that the beam is horizontal, then each is equally being pulled by the gravity of earth. Hence, the two have equal mass. Thus a beam balance is used to measure mass by comparison with other standard mass.

VOLUME

Another important property of matter is its ***volume***, the space that any object occupies. A shadow, an idea, or vacuum are not matter because neither do they occupy space, nor have they any mass. Whether an object is a solid, liquid or gas, it has some volume.

A solid has more or less a fixed shape; it is not easy to change this shape. Some solids have a regular shape; in such cases, their volume can be easily found out by physical measurements. For example, a rectangular block, a cone, a sphere are regular solids. The volume of a rectangular block is the product of its length, breadth and thickness. The standard unit of volume is a ***metre***^{3}. Other units in practice are as under:

1 metre^3 (m^3) $\doteq$ 1000 litres (l)
1 litre (l) = 1000 cm^3 or 100 millilitres (ml)

The litres and ml units of volume are used for liquids and gases only.

How could the volume of an irregular solid, such as a glass stopper, or an iron bolt, be determined? A simple method is to find out the volume of water (or any other liquid) it displaces. A liquid does not have a fixed shape; it can therefore be easily displaced.

Activity 2. Pour water in a measuring jar (graduated cylinder) and note the reading. It gives the volume of water contained in the jar. Now tie the irregular solid to a string and lower it slowly into the water so that the solid is completely immersed (diagram 13). The water level will show a rise equivalent to the volume of the solid. Record the new level of water. Difference in the two readings will give you the volume of the solid.

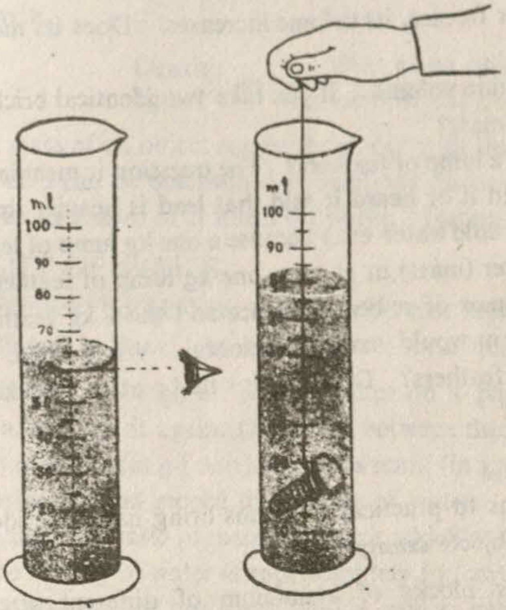


Diagram 13

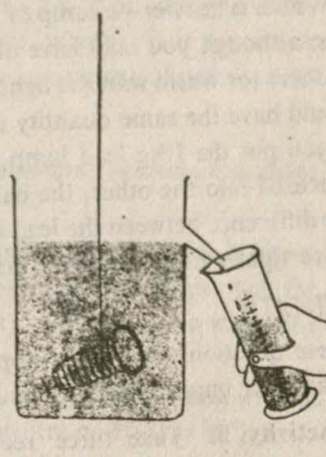


Diagram 14

Activity 3. Another method of finding out the volume of an irregular solid is by using a ***displacement or overflow can.*** Fill the can completely till water overflows through the side tube. Now hold a measuring jar under the side tube and slowly lower the solid in the water till the solid is completely immersed (diagram 14). The solid will displace water equivalent to its own volume; this water is collected in the measuring jar and its volume determined.

If a solid floats on water, for example a cork piece, its volume cannot be determined by the above displacement method. In such a case, a massive lump called a ***sinker*** is used.

Activity 4. Pour water in a measuring jar. Tie the sinker to a thread and lower the sinker in water till it is completely immersed. Note the reading. Now tie the cork piece and the sinker together and lower them in water till both are completely immersed; note the reading on the jar again. The second reading is more than the first one by a quantity equal to the volume of the cork piece. In this experiment it is essential that the water is not spilled over when the sinker is raised up for tying the cork.

CONSERVATION OF MASS AND VOLUME

Any particular object has a fixed mass; does it have a fixed volume? We know that the volume of an object increases with increase of temperature.

Would its mass also change?

When a certain "quantity" of water freezes, its volume increases. Does its mass also change?

A brick has a certain mass and a certain volume. If you take two identical bricks, will the volume be double? and the mass?

Which is heavier—a lump of lead or a lump of feathers? The question is meaningless, although you may have often read it or heard it said that lead is heavier than feathers (or warm water is lighter than cold water etc.) because a one kg lump of lead would have the same quantity of matter (mass) in it as a one kg lump of feathers. If you put the 1 kg lead lump in one pan of a beam balance and the 1 kg feather squeezed into the other, the balance arm would remain horizontal. What, then, is the difference between the lead and the feathers? Do you think that matter is packed more tightly in one than in the other?

DENSITY

These questions, and their applications to practical problems bring us to the idea of another important property of an object: ***density***.

Activity 5. Take three rectangular blocks of aluminium of different sizes. Measure the sides of each block, and hence the volume. Find their mass with a beam balance. Record your observations in a table as shown below:

Block	*Volume* (cm^3) *length × breadth × thickness*	*Mass* (*g*)	*Mass of 1* cm^3 (g/cm^3)
A	90	243	243/90=2.7
B			
C			

The volume of a block tells how many cubes of 1 cm side make up the block; for example, block *A* has the same volume as 90 cubes of each 1 cm side. Hence, the mass of 1 cm^3 of the block can be calculated. This value is recorded in the table as shown.

You will find that for any block of aluminium, the ratio mass/volume, which gives the mass of each 1 cm^3, is the same.

Repeat the experiment for blocks of other materials like iron, glass, brick, etc. and in each case find the mass per cm^3. Make a list in order of "heaviness"; you now have a scientific way of finding out which material is heavier than another because in each case you have found the mass for one unit cube.

Equal volumes of different materials have different mass; also, as in the case of lead and feathers, equal masses of different materials occupy different volumes.

The mass of a unit volume of a material is known as its density. Mathematically, we could write

$$\underset{(g/cm^3)}{\text{Density}} = \frac{\text{Mass of an object (g)}}{\text{Volume of the object } (cm^3)}$$

The mass of an object can be found out with the help of a beam or spring balance. Its volume can be determined by methods discussed earlier, whether it is regular or irregular in shape, or it floats on water. Hence, density can be calculated.

DENSITY OF WATER

Unlike solids, liquids have to be carried and kept in containers. Hence, the mass of a liquid is found out by difference-measurement.

Activity 6. Weigh an empty beaker on a physical balance. Now fill it about 2/3rd and weigh it again. Difference between these two weights would give you the weight of water (in g-f unit), hence its mass (in gram unit). Now pour the water in a measuring jar and record the volume of water.

Calculate the ratio of mass to volume which is the density of water. You will see that the density of water is approximately 1 g/cm^3 (or 1 kg/litre or 1000 kg/m^3).

Now take one or two other liquids such as kerosene, engine oil, mercury etc. and find out their densities. The density of mercury is about 13,500 kg/m^3 or 13.5 g/cm^3.

PROBLEMS

1. By calculation, complete the following table:

Density	*Volume*	*Mass*	*Density*	*Volume*	*Mass*
8.9 g/cm^3	25 cm^3	— g	—g/cm^3	20 cm^3	210 g
2.5 g/cm^3	— cm^3	100 g	0.09 kg/m^3	25 m^3	— kg

2. How would you expect the density of milk to change if (*a*) cream was removed from it, (*b*) water was added to it?
3. A piece of metal has mass 113 g and is put into a measuring jar containing water. Calculate the density of the metal if initial reading is 70 cm^3 and the second reading is 80 cm^3. Which metal is this?
4. A ***burette*** is a glass tube with a tap at the lower end and is marked in cm^3 to indicate the volume of a liquid it contains. From the following data, find the density of turpentine oil:
   Mass of empty beaker = 205 g
   Burette reading before running oil = 1.5 cm^3
   Burette reading after running oil = 26.5 cm^3
   Mass of beaker + turpentine oil = 227 g
5. An iron girder is 5 m long, 25 cm wide and 20 cm thick. Find its mass, taking the density of iron to be 7.8 g/cm^3.
6. A window pane is 1 metre square and 3 mm thick. Find its mass, if density of glass is 2.5 g/cm^3.

4

Light and Sight

"Switch on the light, please!" In an absolutely dark room, it is impossible to see around us. Strike a match or light a candle stick, and they give out some light making objects around us faintly visible. If however we open a window to admit sunlight, the visibility becomes better. All these objects which give out light, *e.g.*, a burning match stick, a glowing electric lamp, the sun, etc. are called ***luminons*** objects. Even the tiny firefly gives out a luminous glow.

Most of the objects that we see around us, *e.g.*, a chair, book, blackboard, etc. do not produce any light of their own. They become visible only when light from some luminous source falls on them. An object which does not give out light by itself is called ***non-luminous***. Even the electric bulb becomes non-luminous when it is switched off.

LIGHT AND SIGHT

Is light the only thing required for seeing? In the dark room, light from the luminous object enabled us to see the other objects around us. Close your eyes and you will not be able to see the objects. A blind man cannot see even during daylight. Thus, no matter what light is available, eyes are essential to obtain vision. Among our senses, eyes have the special property of sight. Do non-luminous objects send light to our eyes?

Although the first source of any light is a luminous object a great deal of light that reaches our eyes is the light sent back from non-luminous objects. The light from the sun scattered by the earth, trees, walls, our clothes, etc. makes our classrooms bright during the day. Moon is a non-luminous object but it scatters the light that falls on it from the sun. Unless a non-luminous object bounces off some light into our eyes, it cannot become visible.

IS LIGHT ITSELF VISIBLE?

Quite often we say "I see light in the room." Actually we are seeing the illuminated parts in the room. In a cinema hall, a beam of light is "seen" from the projector window to the screen; however, if we observe carefully, we notice dust and smoke particles floating in the path of the beam If you shine a torch from one end to the other in a clean and dust-free room, you will hardly "see" any beam of light. But, strike a duster against a hand to scatter chalk dust in the path of light, and the beam of light will appear to become visible. Light itself is not visible but the non-luminous objects in its path can be seen because they bounce off the light to our eyes.

LIGHT TRAVELS IN STRAIGHT LINES

How does the beam of light in a cinema hall appear to travel? Early morning the sun's rays streaming in between the leaves, their path made visible by moisture and dust, appear to go in straight lines. If you shine a torch at night in the open, the beam of light shows a straight path. Searchlights looking for an aeroplane, or the revolving searchlights used by circus shows, can be seen to go outwards in straight lines.

Activity 1. Take three cardboard pieces and make them stand vertically as shown in diagram. Make a small hole in each one of them at exactly the same height from the table. Place a lighted candle at one end so that its flame is at the same level as the holes. Look through the holes from the other end and adjust the cardboards so that the eye, flame of the candle and the three holes are in one straight line. You will notice the flame.

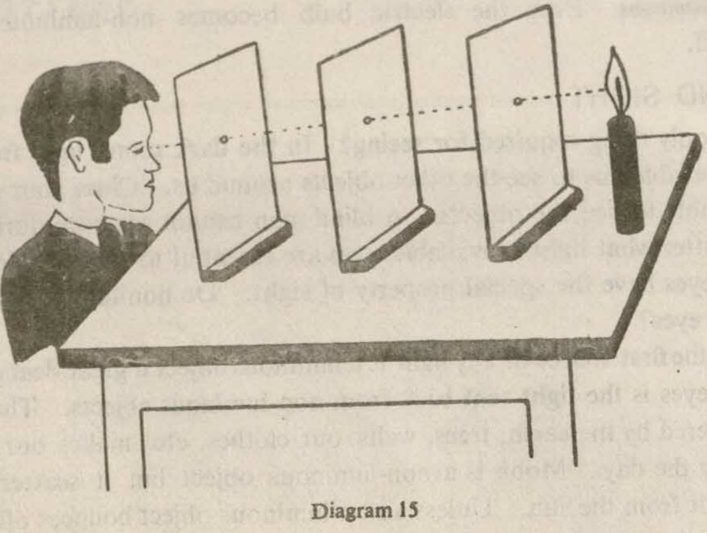
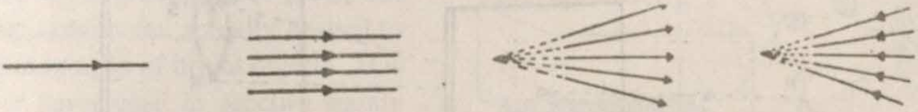


Diagram 15

Now slightly disturb one of the cardboards. Can you see the flame? Again adjust the cardboards so that the flame can be seen once more. You will observe that the flame can be seen only when all the three holes are in a straight line joining the flame and the eye.

Of course all these examples are of broad beams of light. A very narrow path of light is called a ray of light. One could say that if a beam were to be narrowed to a fine line the ray would travel in a straight line.

A ray of light is shown in a diagram by a straight line, with an arrow head showing the direction in which light travels (diagram 16). A beam of light could be divergent, parallel or convergent. In these cases the rays which form the beam are spreading away, going parallel or coming towards each other, respectively. Rays reaching us from a very far off object, such as the sun, are almost parallel to each other.



a ray of light a parallel beam a divergent beam a convergent beam

Diagram 16

OPAQUE, TRANSPARENT AND TRANSLUCENT OBJECTS

In the above experiment we find that light does not pass through cardboard. Hold your palm in the path of light between two cardboards and you can obstruct the light reaching your eye. Such objects through which we cannot see because they do not allow light to pass through them are called ***opaque***. Place two other opaque objects in the path of light.

Now hold a glass block in the path and find out if the flame is still visible. Such objects through which light can easily pass are called ***transparent***. When we look outside a classroom through a window pane, we are looking through two transparent objects: glass and air. Place one other transparent object in the path of light between the cardboards.

Some window panes are not very clear; they allow light to pass through them partially. You may have seen bulbs which give out light but whose filaments cannot be seen; such glass is called ***translucent***. Greased paper, thin polythene sheets and tracing paper are examples of translucent objects.

IMAGE

Activity 2. Take a white opaque screen and place it at a distance from the burning candle. Hold one of the cardboards in between the two (diagram 17). You will notice that if the hole in the cardboard is very narrow, a clear and bright inverted picture of the flame is seen on the screen. This experiment will have to be performed in a dark room, or a bright source of light such as an electric lamp will have to be used, so that the lighted picture on the screen is clear. Every point of the object is sending out rays of light in all directions but only a very narrow beam of light passes through the hole. A ray of light starting from the point *P* will produce a corresponding bright point *R*; a ray travelling from Q will go straight through the hole and produce its corresponding bright or dull spots on the screen. The picture or impression thus received on the screen is called an ***image*** of the candle. How does

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the size of the image vary if the screen is brought closer to the hole, the candle is moved closer to the hole, or the cardboard is moved closer to the screen? It is

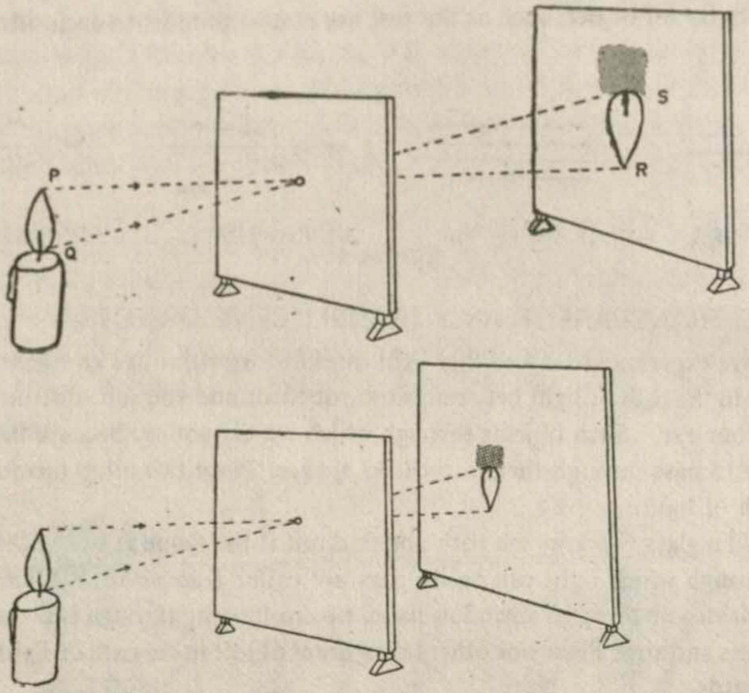


Diagram 17

observed that when the screen is moved towards the hole or the object is moved away from the hole, the size of the image is reduced. Measurement of the distances will show that:

$$\frac{\text{height of image}}{\text{height of object}} = \frac{\text{distance of image from the hole}}{\text{distance of object from the hole}}$$

Such an experiment can be performed in a dark room; a camera is a mini-dark room in which an image is formed on a photographic film or plate.

PIN-HOLE CAMERA

The action of a simple camera can be understood if we construct a pin-hole camera of our own. Take a light-proof cardboard box and cut out a large square at one end. A greased or tracing paper is pasted on the cut out portion. A square hole of about 5 cm size is made in the middle of the opposite surface on which a black paper is pasted (diagram 18). Now make a pin hole in the black paper.

Activity 3. Hold the box at arm's length such that it is between you and a lighted candle, and the pin hole is facing the candle. You will realise that the tracing paper acts as a translucent screen; an image of the candle formed on the screen can be clearly seen. If the tracing paper is replaced by a photographic plate, this pin-hole camera can actually be used to take photographs of bright objects. It is however never used in practice mainly because the light reaching the screen is too small to obtain a bright picture.

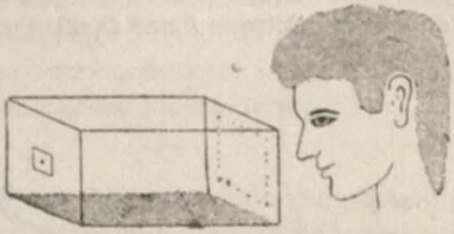


Diagram 18

Now make one more pin hole in the black paper about 1 cm away from the first. You will now see two images of the candle on the screen. Move the camera closer to the candle and observe how the size of the images, and their distance of separation, change. If one of the holes is made bigger, you will see a brighter but less sharp image. A bigger hole is like a number of small holes close together. Each hole will make an image on the screen very close to the others; these images over-lap and produce a final image which is brighter and blurred. In other words, more rays through a bigger hole make the image bright and blurred.

SHADOWS

When you stand in the sun, you see your shadow formed on the ground. When you walk, the shadow moves along with you. Let us find out how these shadows are formed.

Activity 4. Shine a torch towards a wall from a distance of about 2 metres in a dark room. If you hold your palm in the path of the light, you will see a dark patch against a bright background on the wall. Does this dark patch resemble the palm in shape? Move the hand closer to the wall, open the palm with fingers wide apart, and observe how its size changes. Remove the hand and hold a pencil in the path of the beam of light. In each case you will notice that the dark patch resembles the shape, but not necessarily the size, of the object. This dark patch is called the shadow of the object.

Now hold a small sheet of glass instead of the pencil. Can you see a shadow? Repeat with a sheet of transparent plastic. You will realise that a shadow is formed with the stoppage of light by an object. To study shadows we therefore require three objects: (*a*) source of light; (*b*) an opaque obstacle; and (*c*) a screen on which to see the shadow. Does the shadow obtained differ with bigger or smaller sources of light?

Activity 5. A very small source of light *L*, usually called a ***point source***, is prepared.

Hold a sphere in the path of light and observe the shadow (diagram 19). A ray from *L* to *X* will go straight to the screen and illuminate it. The rays *LB* and *LD* will go just grazing along the surface of the sphere and reach the screen at points *E* and *F*, respectively. Between *B* and *D*, all other rays of light will be stopped by the sphere.

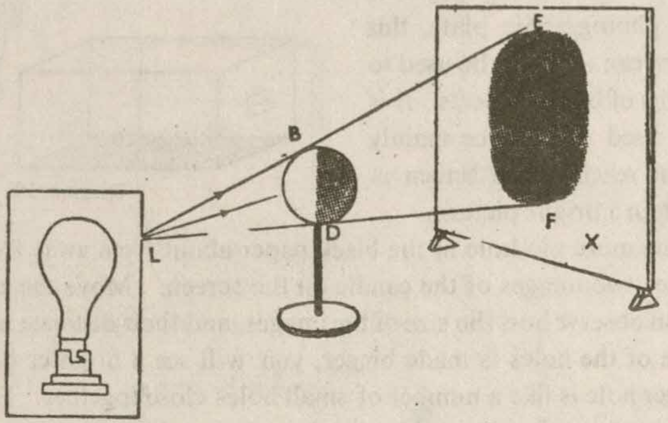


Diagram 19

Why is only half of the sphere brightly illuminated? See how the shadow changes if the sphere is replaced by another obstacle. How does the shadow change if the obstacle is moved closer to the screen? You will notice that the shadow becomes smaller, and remains sharp and equally dark everywhere.

Activity 6. Take a wide source of light and again study the shadow of the sphere.

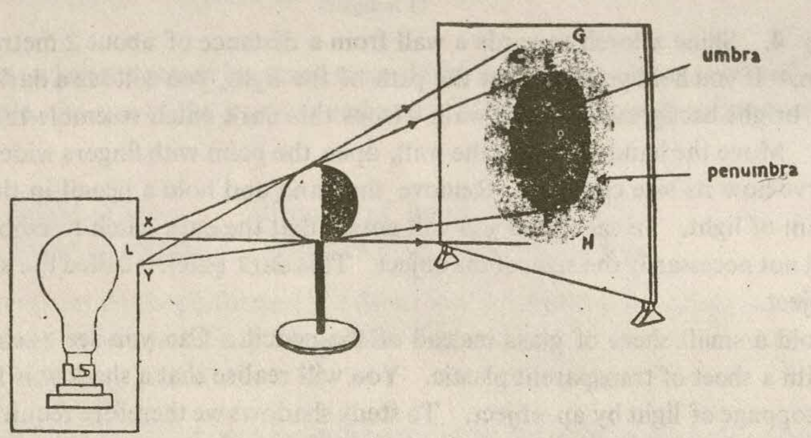


Diagram 20

You will find that the shadow is not sharp this time. One faint and one dark shadow appear to be over-lapping; actually there are two different parts of the same shadow. The dark part of the shadow between *EF* (see diagram 20) receives no light at all and is called ***umbra;*** an eye situated at *A* within the shade of the umbra region would see no part of the source *L*. The fainter part of the shadow is called ***penumbra*** and in this part light is only partially cut off; an eye at *C* within the shade of penumbra region would see the top part, including *X*, of the source *L* but not the lower part which includes *Y*. Outside *GH* the screen would receive light from the entire source. How would the shadow change if the screen is moved away from the source? You will observe that both the umbra and penumbra regions become larger.

PHASES OF THE MOON

In the above experiment it should be noted that only about half of the sphere is illuminated by the source. But from different positions round the sphere, the illuminated portion seen will be different. Similarly, as the moon revolves round the moving earth, one half of the moon facing the sun is fully lighted. The lighted side is fully facing the earth only during ***full moon*** (diagram 21); on the other nights illuminated half of moon surface is only partially seen from the earth. When most of the lighted surface is facing away from the earth (at position *N* of the moon in the diagram), the moon appears a thin crescent and is called ***new moon.*** As the moon takes about 28 days to travel round the earth, its shape seen from the earth increases from crescent at new moon to full moon in about two weeks, and diminishes in two weeks, periodically. These recurring shapes of the visible moon are called phases of the moon. The two intermediate stages at *H* and *L* are called half moon; in terms of the lunar month they are also called First Quarter and Last Quarter, respectively.

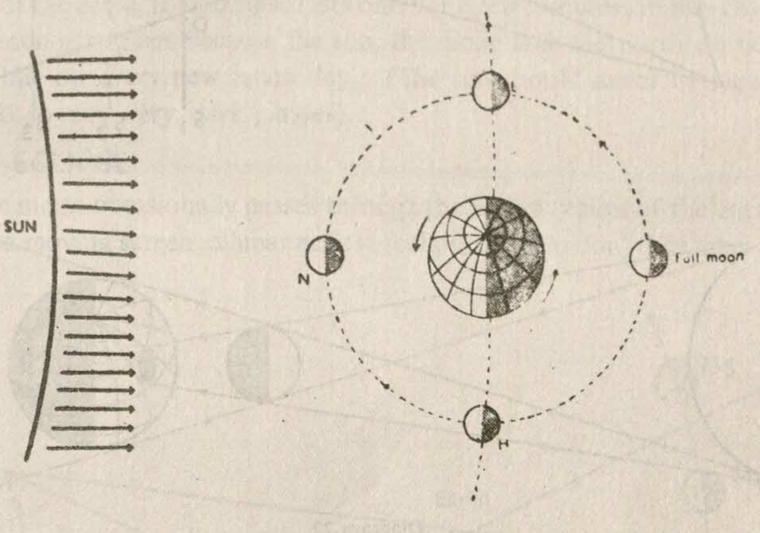


Diagram 21

SOLAR ECLIPSE

If a source of light is much bigger than the obstacle, the shade of the umbra region tapers to a point, while the penumbra broadens as seen in the diagram 22*a*. A screen moved away from position S_1 to S_2 would show a gradually diminishing umbra.

As the moon rotates round the earth, it is natural that the sun, earth and moon sometimes come in one straight line. When the moon comes in between the sun and the earth, the shadow of the moon may fall on some part of the earth; a solar eclipse then takes place. Parts of the earth under umbra will have total eclipse of the sun, while the parts under penumbra will experience partial eclipse (diagram 22*b*). If the earth is in position S_1, there will be an eclipse of the sun in region *AD*, of which the region *BC* will have total eclipse, *i.e.*, the moon will completely obstruct a view of the sun from that region, while there will be partial eclipse in regions *AB* and *CD*. If the earth is beyond position S_2, there can be no total eclipse, *i.e.*, part of the sun will always be visible.

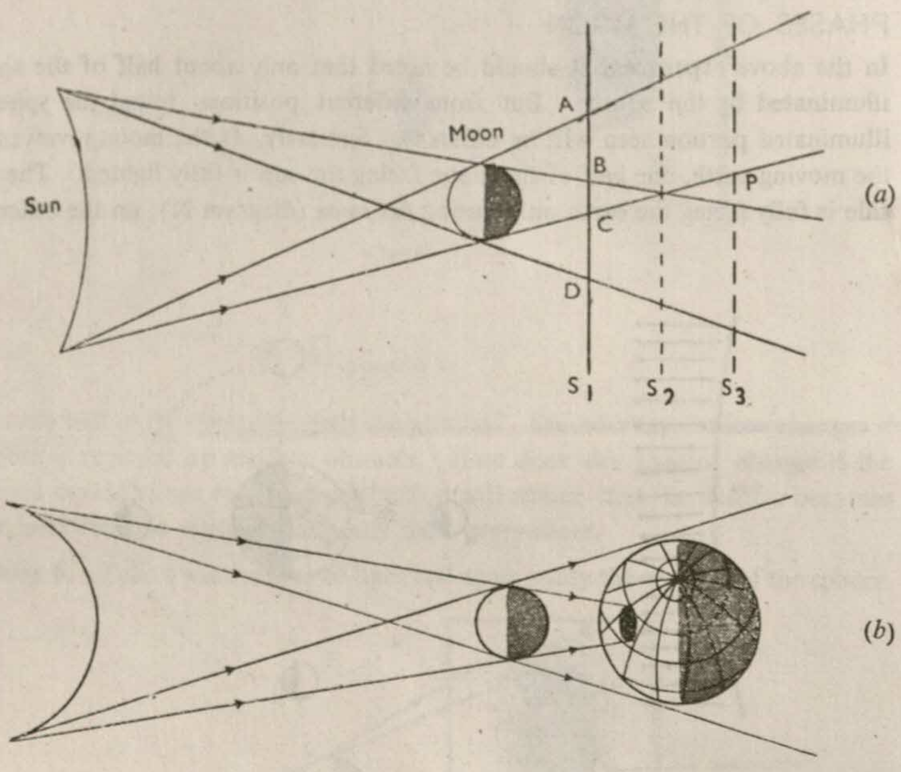
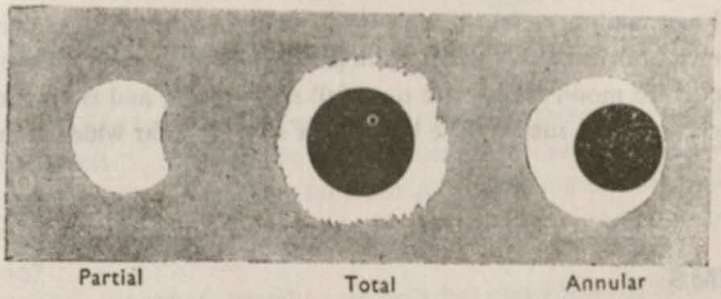


Diagram 22

A very interesting view of the sun can be had from position *P* when the earth is just beyond the umbral shade; the moon then covers the middle portion of the sun while the outer bright ring will be visible. This is called ***annular*** eclipse of the sun.

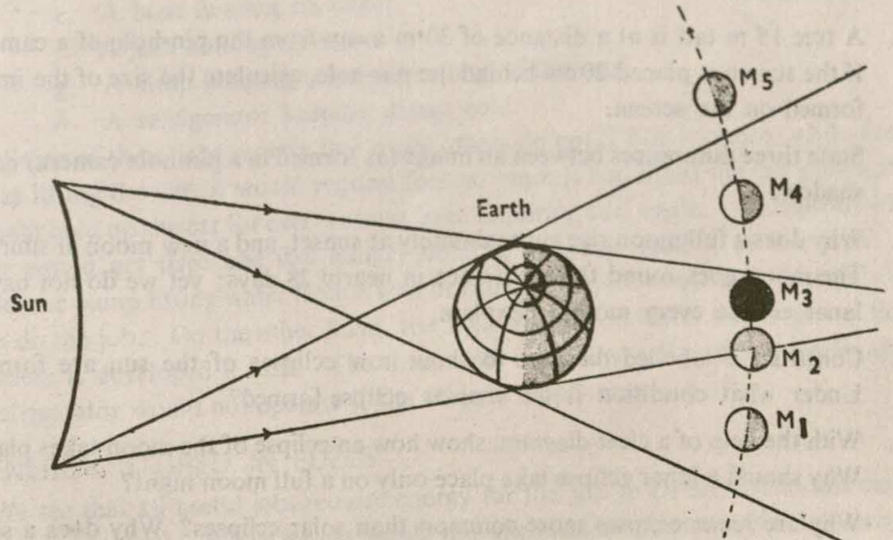
Since the lighted portion of the moon is facing away from the earth, a solar eclipse takes place on a new moon day. Owing to the fast movement of the moon and rotation of the earth, total eclipse lasts only for a few minutes; in any case, it is a rare phenomenon at a place because the sun, the moon and the earth do not come in a straight line on every new moon day. (The sun should never be viewed directly; it is safe to use very dark glasses).



Three types of eclipses of the sun
Diagram 23

LUNAR ECLIPSE

When the moon occasionally passes through the umbra region of the earth's shadow, it acts as a moving screen; a lunar eclipse (eclipse of the moon) then takes place. The



umbra shadow of the spherical earth is always circular at its sharp edge; and this was known as one of the earliest evidences for the spherical shape of the earth. In the diagram 24, M_3 shows the position of a totally eclipsed moon. If the moon is at M_1 or M_4 in the penumbra region of the earth's shadow, the eclipse is partial. Once the moon is out of the earth's shade, as in position M_5, it will be fully bright again. The eclipse of the moon takes place on a full moon night; and is far more frequent than the eclipse of the sun because the earth's shadow is far wider than that of the moon.

PROBLEMS

1. What is the difference between luminous and illuminated objects? Name two luminous objects not mentioned earlier in this chapter. How can one end of a rod of iron be made luminous?
2. How does the image in a pin-hole camera change if (a) the screen is moved further away from the hole; (b) the hole is made bigger?
3. Draw a neat diagram to show how a pin-hole camera forms an image of an illuminated object 1 cm high placed 6 cm away from the pin-hole, when the screen is 3 cm behind the pin-hole. What is the height of the image formed? Check whether the value obtained by calculation is the same as obtained by observation.
4. A tree 15 m tall is at a distance of 30 m away from the pin-hole of a camera. If the screen is placed 20 cm behind the pin-hole, calculate the size of the image formed on the screen.
5. State three differences between an image (as formed in a pin-hole camera) and a shadow.
6. Why does a full moon rise approximately at sunset, and a new moon at sunrise? The moon goes round the earth once in nearly 28 days; yet we do not have a lunar eclipse every month. Explain.
7. Construct a labelled diagram to show how eclipses of the sun are formed. Under what condition is an annular eclipse formed?
8. With the help of a clear diagram, show how an eclipse of the moon takes place. Why should a lunar eclipse take place only on a full moon night?
9. Why are lunar eclipses more common than solar eclipses? Why does a solar eclipse last only for a very short time?
10. What is the difference between an eclipse and phases of the moon?

5 Energy from Fuels

After a hard game or a long swim, one often hears the comment : "Oh, I am finished! I have no energy left." Most people feel like this at the end of the day after having done a good day's work. The energy they had in the morning has been spent during the day. A hearty meal and you hear: "Ah ! I am full of energy again." What does food do?

Food enables us not only to breathe and think but also allows us to do things like running stairs, carrying books to school or playing a game of football. Just as a motor car needs fuel to run, so do our bodies need fuel which is supplied in the form of food. Can you think of all the jobs that require fuel?

FUEL USING JOBS

Here is a list of eight jobs. Which of them require fuel?

a. Riding a bicycle to go to school.
b. Using an electric pump to lift water from a deep well.
c. A torch with batteries giving light.
d. Holding a brick in one hand over your head.
e. A boat floating on water.
f. A jack holding up a car.
g. A lamp hanging from the ceiling of the roof.
h. A refrigerator keeping things cold.

Some of these jobs require fuel while others do not. For instance, while the jack was lifting the car, it would require fuel but once it had lifted the car sufficiently, it could hold up the car for ever without ever requiring fuel again. On the other hand, we would get tired and feel hungry holding a heavy load over our head. The electric pump lifting water from a well or riding a bicycle would always require a fuel to do the job. On the other hand, the boat floating on water would go on floating unless it developed a leak. The torch will need new cells after a while, and the refrigerator would not operate if the electric supply were cut off.

ENERGY STORED IN FUELS

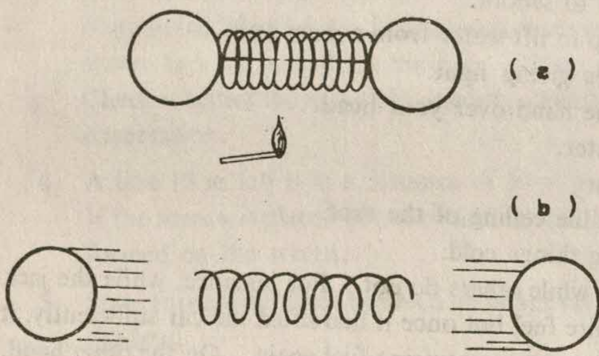
We see that all useful jobs require energy for the job to be done, and this energy is suppied by fuel. When we eat food, the chemical reactions in our stomach allow the energy stored in the food to be released for our activity; it is usual to say that energy is stored in the form of chemical energy. The same sort of thing happens in a cell which is used to light a torch, or in coal required to run a steam engine.

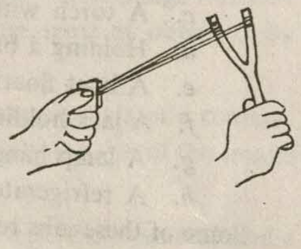
What happens to the stored chemical energy when a cell needs replacement, or once coal has turned into ash? Does it simply disappear? As a matter of fact, the light and heat that we get from these are also forms of energy because these can be used to do useful jobs. Instead of the chemical energy simply disappearing, it has conveniently changed its form.

DIFFERENT FORMS OF ENERGY

When you wind a clock, you transfer some of your energy to store energy in the spring of the clock. Energy stored in springs is known as ***strain energy*** or ***elastic energy.***

Activity 1. Hold two metal spheres together by a strong thread, with a spring compressed in between them (diagram 25). Now cut the thread with a blade. The spheres move apart with some speed. The spring attains its original shape and in so doing transfers its strain energy to the spheres. The stretched rubber band of a catapult can throw a pebble with great speed. An arrow shot from a bow utilises the strain energy which we give to the bow when we stretch the string.





Strain to kinetic energy

Diagram 25

Since lifting load requires energy, it gains this from the kinetic energy of the trolley in the above experiment. Running water of a turbulent stream can wash away a bridge; it can also be put to use to turn a turbine to produce electrical energy. Similarly, blowing wind can uproot trees and cause much damage; its kinetic energy can also move the vanes of a wind mill.

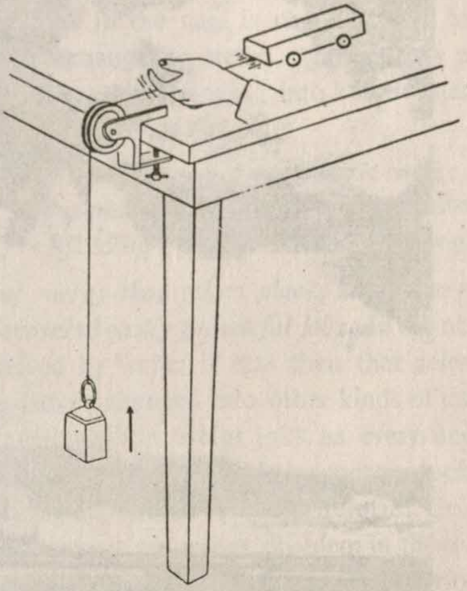


Diagram 26

POTENTIAL ENERGY

When you lift a load to a higher level, the job requires fuel. How does the energy of the fuel get utilised? If you pick a brick from the floor and let it fall upon a thin wooden plank, the plank breaks. Breaking of a plank is a job that needs energy. Where did this energy come from?

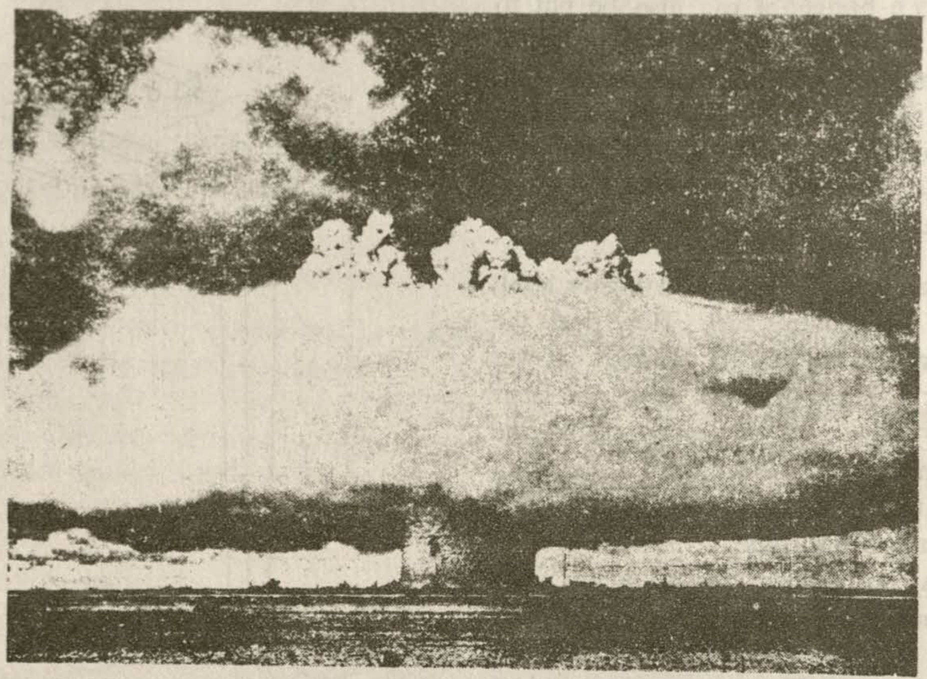
A raised load can do a job while going down. Greater the height from the ground, more is the job that the load can do. Hence we say that a raised load has energy due to its raised position. The scientific name for this energy possessed by an object due to its raised position is ***gravitational potential energy***. If the name sounds too long, you could call it simply potential or uphill energy. The pull of the earth (gravity) is responsible for it.

Other forms of energy are ***electrical energy, light energy, heat energy*** and ***nuclear energy***. Heat received from the sun dries up ponds, and changes water from the seas into clouds. These clouds carried by the winds form the monsoon rains over most of India. Light energy from the sun helps plants to grow. When you think of huge amounts of energy, you may think of hydrogen or atomic bombs, in these explosions nuclear energy from some elements is utilised to give heat, light etc.

ENERGY TRANSFORMATIONS

Can you think of some other forms of energy? The idea that energy changes from one form to another when jobs are done, is a very important idea in science. However, what name we give to a particular form of energy, or whether it is different in any way from energy in some other case, is a matter of discussion. We give special names for the sake of convenience, so that we can remember these special cases.

Activity 3. Hammer a piece of lead or any other metal a few times. Touch the metal and you will find that it has become warm. What are the energy changes?



Courtesy USIS

The blast of an atomic bomb
Diagram 27

You could write the enrgy changes like this: ***chemical energy in food*** TO ***potential energy in hammer*** TO ***kinetic energy in hammer*** TO ***heat energy in the metal.***

Activity 4. Do the following experiments and record the energy changes that take place:

a. A model steam engine lifts a load from the ground.

b. A bicycle dynamo lights a lamp when we ride the bicycle.

c. Work an electric bell with a battery.

d. Tie a spring to a stand and let a brick hang from it.

e. Tie a metal object with a string and swing it from a stand.

In all these experiments, energy of one kind was transferred into another and sometimes there were more than one changes before it appeared in the final form. It is important to note that in each of the cases, energy was transferred FROM one kind TO another kind. It is more like money flowing into your pocket as you earn it, and then flowing out again as you spend it. You should be able to account for the transfer of money by saying that you get it FROM Mr. X which was then transferred TO Mr. Y for which you got some chocolates in return. Similarly, you think of energy being transferred FROM one kind TO another kind for which you got some useful work in return.

In a steam engine, the chemical energy stored in the coal is changed into heat. The heat is taken by water in the boiler which changes to steam. The energy possessed by steam pushes the piston in the cylinder, thus changing into kinetic energy. We could write this series of changes as follows:

chemical energy →	***heat energy*** →	***molecular energy*** →	***kinetic energy***
coal used as fuel	produced during burning	possessed by expanding steam	moving piston and then engine

In real life, of course *at each transfer of energy that takes place, some energy is changed in the form of heat and cannot be recovered easily for useful jobs*. In the above example the amount of energy that is received by water is less than that released from the burning of coal. Although heat can be changed into other kinds of useful jobs, less and less of energy becomes available for useful jobs as every energy transformation releases waste energy. Thus all over the world the energy stocks of stored energy in coal, oil, wood etc. are being depleted in running factories, driving cars, lighting houses, etc. It has therefore become an urgent problem in the world how to regulate the spending of energy so that it lasts mankind for a long period to come.

PROBLEMS

1. Write the series of energy transformations that take place in the following examples:
   a. A Diwali rocket is fired from the ground.
   b. A cricket ball is thrown up, it returns to the ground and stops.
   c. A swinging pendulum gradually comes to rest.
   d. Blowing up a balloon.
   e. Lights in a car are switched on when the car is not running.
   f. Scooter lights are switched on.
   g. A magnet lifts a nail from the table.
2. Wind a toy car and allow it to run on an inclined table, moving slightly upwards. State the energy changes which take place.
3. Cut out a spiral from a thin card board and suspend it from the centre (diagram 28). Place a heater or burner under it, taking care that the spiral does

not catch fire. The suspended spiral moves round and round. Where did it get the energy?

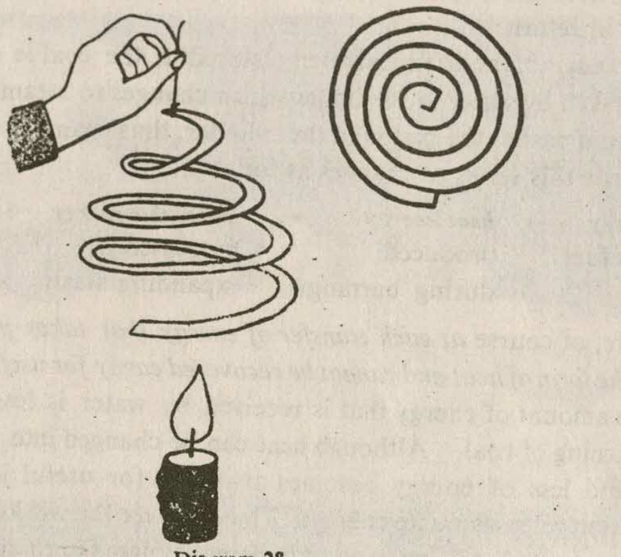


Diagram 28

4. Rub a finger vigorously on top of a table. Rub both your hands against each other. In each case you feel warm. State the energy transformations taking place.

5. Two teams pull a rope in a tug-of-war, but the result is a draw even after a few minutes. Mention the energy transformations taking place.

6 Heat and Temperature

The food that we eat provides the chemical energy which changes into heat to keep our body warm. Petrol is used to drive cars and scooters; coal and diesel oil are used to run trains. Gas, coal or wood provide heat to cook our food. Many other jobs we do, and those which machines do for us, require fuel; the fuel burns giving off heat. While man has learnt to control and use heat for doing jobs, fuels are getting consumed and have to be paid for. It therefore becomes necessary to learn what heat does, how it is measured, and how waste could be avoided.

SOLAR HEAT

The most abundant and free source of heat energy is the sun. It provides us warmth during the day. The heat may make our life uncomfortable during summer but it is most welcome in the winter. Plants use heat energy from the sun for their growth. Man and animals eat and live on plants; without this heat, life on earth would be impossible.

Activity 1. On a clear sunny day hold a magnifying glass (converging lens) in one hand and a piece of carbon paper in the other just below the lens. Move the lens closer or further away to form a small bright spot on the paper (diagram 29). If you hold your hand steady for a while, the paper starts fuming.

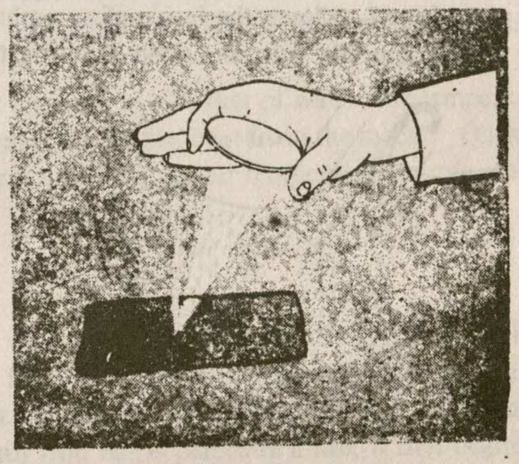


Diagram 29

When all the heat reaching the lens is thus brought to a point, it can burn a hole into the paper. Imagine how much energy must be reaching the total surface of the earth each day; it has been calculated that this would be equal to the heat energy released by burning more than 100 million tonnes of coal.

Another method to collect the heat spread over a wide surface is to use absorbers. Solar heaters absorb energy and reflectors use heat from the sun to warm water. Diagram 30 shows a solar heater constructed in the Central Building Research Institute, Roorkee.

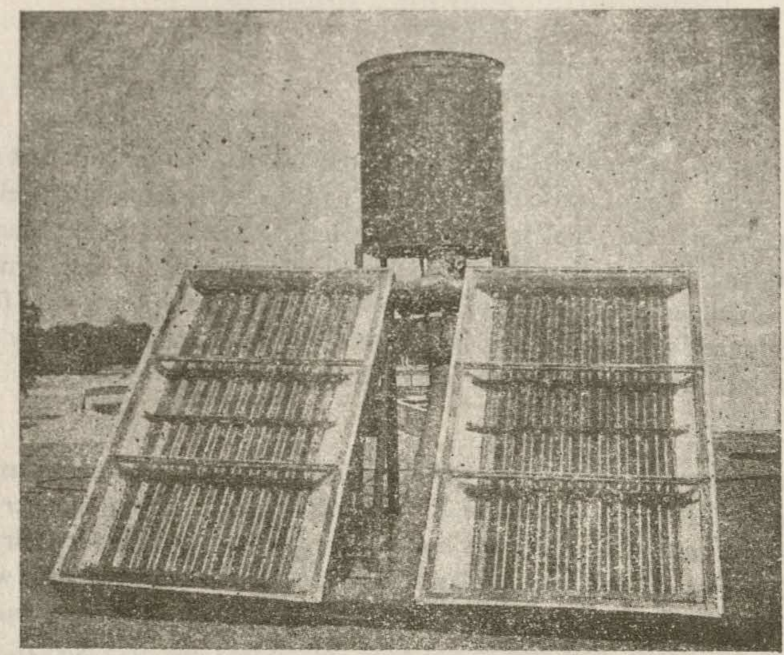


Diagram 30

Activity 2. Cover the inside of an umbrella with metal foil from tea boxes. Set up the umbrella with its handle pointing towards the sun. If now you hold your hand near the handle (diagram 31) and move it up and down, you will feel very hot near the ribs (spokes) which join the handle.

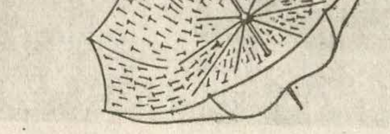


Diagram 31

Solar cookers are similarly constructed and have been used to cook food. They have huge reflectors of the shape used in car headlamps.

TEMPERATURE

In all these experiments we notice that heat from the sun and other sources makes objects hot; removal of heat makes them cold. Temperature is the name given to the degree of "hotness or coldness" of an object on a chosen scale. A thermometer is used to measure the temperature of any object.

A thermometer is an instrument specially designed to measure temperatures of objects. It is based on the principle that materials expand when heated and contract when cooled. The most common forms of thermometers contain a liquid, mercury or alcohol, as the material. Most of the liquid is in a bulb; the thermometer therefore gives the temperature of an object around the bulb. A thermometer also has a very narrow stem which contains very little liquid; it is sealed at the top when all air is driven out of the space at the top. The stem is used to mark the temperature. Like all other units of measurement such as second, metre, kilogram, etc. the °C (degrees celcius) is a "man-made" unit of temperature measurement.

Activity 3. Get hold of a liquid-in-glass thermometer and place it on the table for a minute or two. Note the level of liquid in the stem which indicates the normal room temperature. Pick the thermometer, hold it in your closed hand, and observe the liquid level. As the level rises, it shows an increase in temperature due to heat received from your hand.

The temperature is read on a chosen scale in degree celcius or °C. If a person has high fever, one could easily know about this by touching his body. However, our sense of touch would be very unreliable if the person had slight fever. Normal human body temperature is about 36.5°C, and can be read by holding the bulb of a thermometer under the arm pit.

When an object is heated, its temperature rises. In other words, heat is a cause of which temperature is the effect.

If a cube of ice is added to a glass of water, the temperature of the water noticeably falls. The water gives away its heat to the ice and a result of this heat transfer is a drop in water temperature.

However, if a red hot piece of metal is dropped in a beaker of water, the temperature of water is seen to rise. Thus the water has gained heat from the metal. Quite obviously, heat transfer takes place from a body at a higher temperature to one at a lower temperature.

HEAT AND LIGHT

It is a familiar observation that when we switch on a lamp, it gives light as well as heat; a heater used primarily to give heat, also gives out light. The sun gives us both light and heat. In fact, any object which becomes sufficiently hot gives out light. When a heater is switched on, or an iron bar is placed in a fire, it first begins to glow with a dull red colour when the temperature reaches about 550°C. As the temperature is further increased, the colour changes to bright red. The temperature of a filament of a bright glowing lamp is more and it gives a yellow-hot or white hot light. The fact that the colour of a hot object changes with temperature is useful to estimate the temperature of distant objects; the surface temperature of the sun is about 5500°C.

HEAT RADIATION

Heat energy from the sun reaches us through the intervening 'space' in a special way called ***radiation***, or more correctly ***infra-red*** radiation. Infra-red and light have many similar properties. They can both be reflected; they can be brought to a point by a lens showing a property called ***refraction***. Infra-red radiations travel in a straight line, a fact which can be proved by placing a cardboard between our eye and the sun thus stopping heat and light both. Since the intervening 'space' between the sun and the earth is almost empty, it is obvious that infra-red and light require no medium to pass through.

We know that light itself is invisible but makes other objects visible when it falls on them and gets reflected to our eyes. In the same way infra-red itself is not hot; objects which receive infra-red radiation absorb the energy and become hot. The 'space' is not only empty but also cold because there is no matter to absorb the infra-red. Mercury, the planet closest to the sun, rotates round the sun in such a way that one part always faces the sun; the temperature on this surface is very high, while it is extremely cold on the other side.

During a total solar eclipse, both light and infra-red are cut off at the same time; the drop in temperature is sudden which proves that infra-red radiations and light travel with the same speed.

Activity 4. Take two identical tin cans; paint one of them black and keep the other shining from outside. Fill them half with water, cover them with cardsheets which hold a thermometer, and place them on a table in the open under direct sun light. (This ensures that infra-red radiations from the sun are also striking them directly.) Note the mercury levels in the two thermometers which would show that the temperature of water in the beginning of the experiment is the same (diagram 32). In a few minutes, the thermometer in the black can records a rise in temperature.

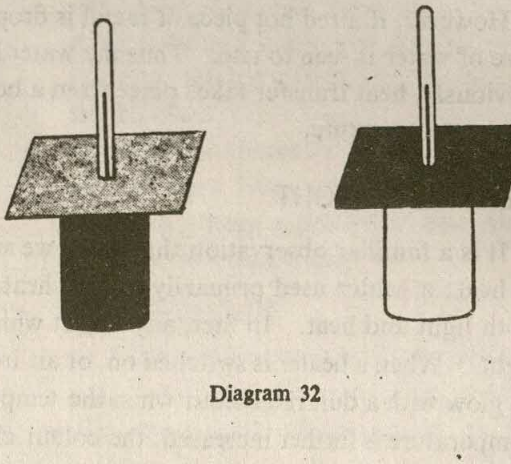


Diagram 32

Now replace the water in both the cans with hot water, place them in the shade and record the temperature. In a short time it would be noticed that the water in the black can cools faster than that in the polished can.

The first experiment shows that black surface absorbs infra-red better than polished surface; the second experiment shows that black surfaces radiate infra-red more effectively than polished surfaces. White or polished surfaces are thus good reflectors but poor radiators of radiant heat. For the same reason, white and faint-coloured clothes are preferable in summer than dark coloured clothes. In winter, dark clothes feel warmer. The back of a refrigerator and hot plates are coloured dull black to radiate heat effectively.

CONDUCTION

All objects emit heat radiation although objects at higher temperature will emit more than others. When two objects having a difference in temperature are near each other or are in contact, radiation is not the only method by which heat is transferred from the hotter to the colder object.

Activity 5. Fix a metal rod horizontally with the help of a retort stand. Cut several sections of a candle and fix them to the rod along its length as shown in diagram 33. Heat one end of the rod. You will see that the candle pieces fall one by one from the heated end. As heat reaches a wax piece, it melts and the piece falls down. Thus heat is transmitted along the rod from the hot end towards the cold end. This method of heat transfer is called ***conduction.***

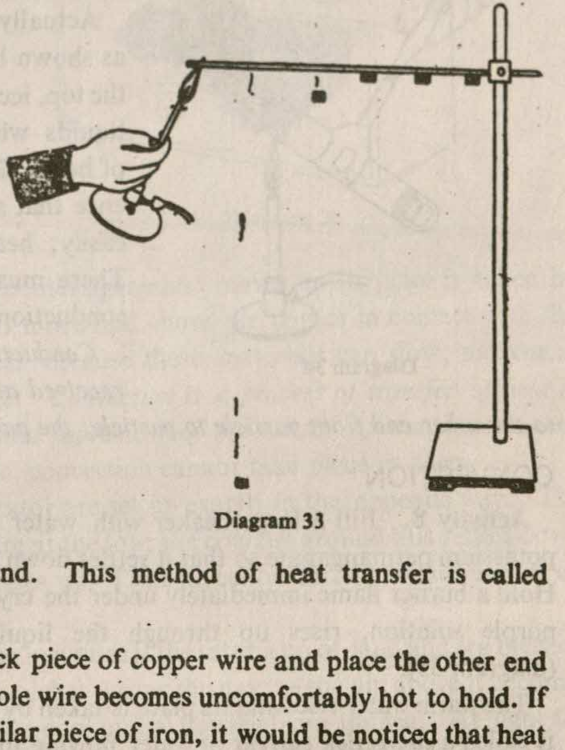


Diagram 33

Activity 6. Hold one end of a thick piece of copper wire and place the other end over a burner flame; very soon the whole wire becomes uncomfortably hot to hold. If the experiment is repeated with a similar piece of iron, it would be noticed that heat reaches slower to the other end; the end in the flame may become red-hot but the other end could still perhaps be held. If a glass rod is used instead, the end in hand remains comfortably cold.

All metals conduct heat but the above example shows that copper is a much better conductor of heat than iron. Glass rod in the above example does not allow heat to flow through it and is called an ***insulator*** or a bad conductor of heat. Pans, kettles and other cooking utensils are made of metal so that they can quickly and effectively transfer heat which they receive from the source below to the material inside. The handles of kettles, soldering irons, pans etc. are often made of insulators such as wood or plastic so that one could hold them in hand. You may have seen blocks of ice covered with saw dust to prevent them from melting.

Activity 7. Put some ice inside a boiling test-tube. Push a piece of wire gauze through the tube so that it traps the ice inside. Now fill up the tube with water and hold the open end over a burner flame carefully. The water soon begins to boil but the ice is still not fully melted (diagram 34). If the experiment is repeated by heating the tube from below with ice floating on top, the ice quickly melts.

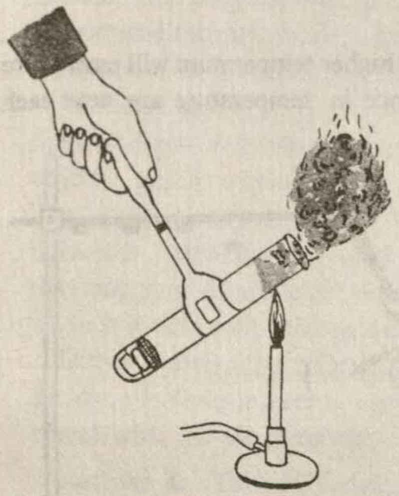


Diagram 34

Actually, water is a poor conductor of heat as shown by the fact that when it is boiling at the top, ice trapped below it does not melt. All liquids which are not metal are bad conductors of heat. However, it is also a common experience that a liquid heated from below gets hot easily; heat flows easily upwards in liquids. There must therefore be a method other than conduction which helps this process.

Conduction is a process in which heat energy received at one end of a material is transferred to the other end from particle to particle; the particles themselves are not on the move.

CONVECTION

Activity 8. Fill a large beaker with water and carefully introduce a crystal of potassium permanganate so that it settles down at the bottom with least disturbance. Hold a burner flame immediately under the crystal. The crystal dissolves to form a purple solution, rises up through the liquid and comes down from the side (diagram 35).

The warm water rises and its place is taken by cold water from sides. It forms what is called a ***convection current*** of water flowing in a sort of closed circuit. Convection thus helps the whole mass of water to mix freely, to receive heat and to warm up.

Activity 9. Convection in air is shown by using an apparatus which consists of a rectangular box with a sliding glass front and two chimneys fixed on top (diagram 36). A lighted candle is placed below one chimney, and the glass front is closed air tight. Now a smouldering paper is held over the other chimney. The smoke is dragged inside and shows the setting up of convection current due to the lighted candle.

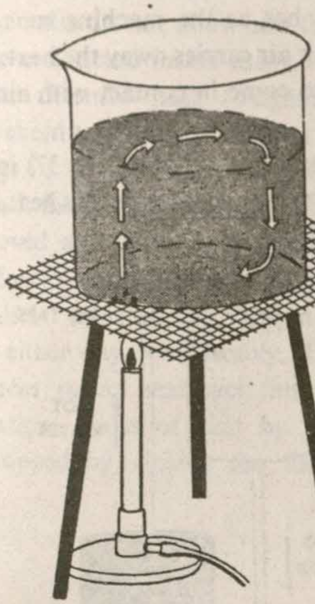


Diagram 35

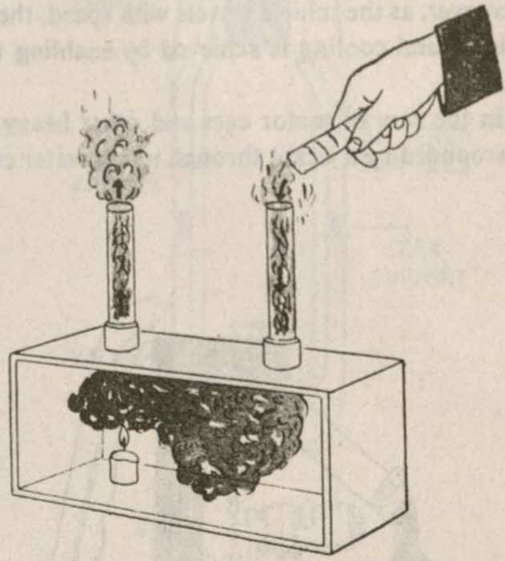


Diagram 36

As warm air around the flame becomes ***lighter*** and moves up its place is taken by cold air coming from the side; thus more and more air comes in contact with the flame. Liquids and gases are fluids because these materials can flow; movement of particles within them is possible. *Convection is a process of transfer of heat in which fluids are heated by the actual movement of particles.* As mass movement of particles is not possible in solids, convection cannot take place in them.

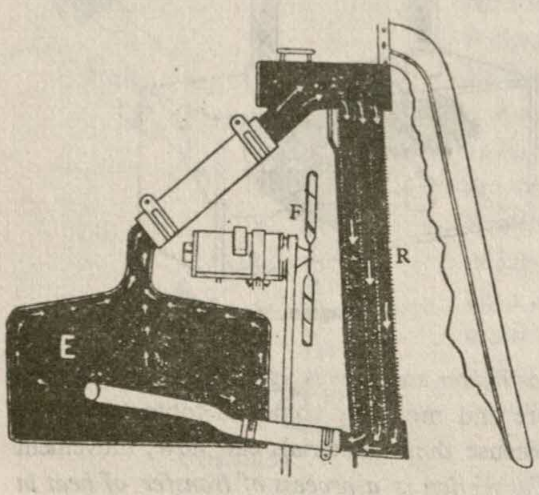
Convection currents in a refrigerator are set up exactly in the opposite way. The freezing chamber and the ice box are at the top; the cold air around this settles down while warm air from lower layers rises up. The convection currents which are set up keep the food stuffs cold.

A common example of convection in nature is the setting up of land and sea breezes. At coastal places the land gets hot quicker during the day; as the air above it becomes warm and rises, its place is taken by a cool breeze flowing from the sea. At night the land cools quickly when a breeze flows from land to sea. Coastal areas therefore have a temperate climate.

Ventilation is a practical example of the use of convection currents used to keep inside of rooms cool and fresh. The air we breath out is warmer and rises while its place is taken by fresh air coming inside from the windows; ventilators at the top provide outlet for the stale and warm air. Ocean currents and trade winds are examples in nature of large scale convection currents set up due to this difference of temperature in air and water.

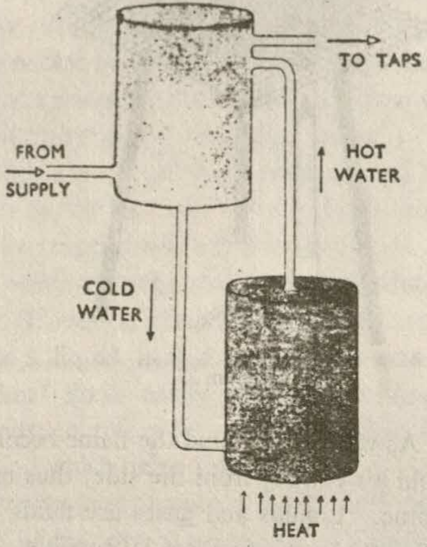
The engines of scooters and motor cycles become hot as the machine runs. However, as the vehicle travels with speed, the surrounding air carries away the heat; this natural cooling is achieved by enabling the engine to come in contact with air easily.

In the case of motor cars and other heavy vehicles, the engine *E* (diagram 37) is surrounded by a jacket through which water circulates carrying away the excess heat.



Cooling system in cars

Diagram 37



Principle of hot water system

Diagram 38

This circulation due to convection currents is aided by cooling of water at the ***radiator*** *R*. A fan *F* behind the radiator sucks in air, thus helping water in radiator to cool quickly.

Hot water system in many hotels and houses is based on the principle of convection. It essentially consists of two tanks; the lower tank (diagram 38) is called the boiler. Hot water from boiler rises and goes into the upper tank, from where it is taken out for use. As the water is used up, cold water from the suppply system enters the circulation to be heated in the boiler.

It is important to know that both water and air are bad conductors of heat. If they are trapped and no movement is allowed, they behave as good insulators like felt or feathers. Open string vests which trap air keep our body warm. Double-walled houses keep rooms warm in winter as heat inside is trapped; during summer these walls do not allow heat from outside to be conducted inside easily.

The thermos flask (diagram 39) is a household appliance in common use to keep things in it warm or cold. It is a double-walled flask. Air between the walls is removed and they are polished. As both conduction and convection require particles for their transfer, the vacuum stops heat flow either way considerably. The polished surfaces reflect heat back thus minimising radiation. Loss of heat by evaporation is stopped by closing the flask using a cork.

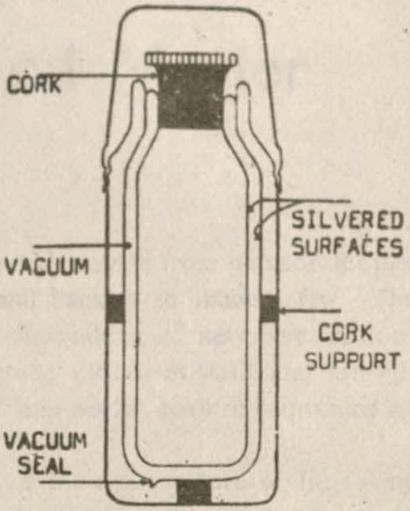


Diagram 39

PROBLEMS

1. State three ways in which heat radiation from the sun resembles light.
2. State the four ways of heat transfer which cool a hot cup of tea kept on a table. How could the cooling be minimized?
3. Explain how heat losses by conduction, convection and radiation are reduced in a thermos flask.
4. Explain why (*a*) A stone floor feels cold to bare feet in winter but a carpet in the same room feels comfortably warm; (*b*) A blanket wrapped around our body in winter keeps us warm, but helps a block of ice not to melt; (*c*) If rods of iron and copper are held in hand and their other end placed over a fire, tip of the iron rod becomes red-hot while that of the copper rod does not seem to glow.
5. Describe an experiment, and draw a clear diagram, to show that water is a poor conductor of heat. How does then water get heated easily when a container full of water is kept over a burner?
6. When a glowing cigarette is placed in an ash tray, the smoke is seen to curl upwards. Explain why this happens, and show with the help of a diagram how this fact can be used in ventilation of rooms.

7

Chemistry and Matter

If you look around your home, you will see many articles made from plastics: the pen you write with, electrical switches, toys, films and buckets to name a few. The search for new materials for our clothing led to the making of new fibres such as nylon, terylene and orlon. These fibres are strong, crease-resistant and are not attacked by moths. These are all examples of "man-made" materials invented by scientists.

From fertilisers for raising the yield of crops to the manufacture of life saving drugs, scientists are constantly engaged in the study of ***chemicals***. *Chemistry is the study of materials, what they are made of, and the changes they undergo.* Our way of living and the society have been greatly influenced by the work of chemical scientists.

STATES OF MATTER

We often see water from ponds drying out quickly during summer. Water from the sea changes into vapour and forms clouds. Water changes into vapour not only over ponds, lakes, rivers and oceans, but also on the surface of soil, skin and wet clothes hung for drying. This process is called ***evaporation***.

When a candle burns, have you noticed the wax at the top changing into liquid? If the candle is blown off, the liquid wax changes back to solid.

Activity 1. Place a few pieces of ice in a beaker and cover it with a watch glass. Place the beaker on a tripod stand for heating (diagram 40). Observe the changes that take place, and also the under-surface of the watch glass.

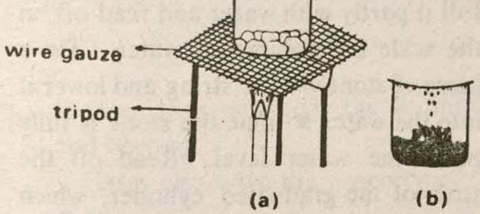


Diagram 40

The ice cubes take heat and ***melt*** into water. If the heating is continued for some time, the water changes into steam. When the steam rises up in the beaker, it comes in contact with the watch glass and gets cooled; the steam then changes back to water and gathers in the form of drops on the underside of the watch glass.

Now take a portion of the hot water in a test tube and allow it to cool. Put the test tube in a mixture of ice and common salt, called ***freezing mixture***. You will notice that the water changes to ice within a few minutes. You may have seen water changing into ice when cooled in a refrigerator.

Matter is the stuff of which all substances are made. Solid, liquid and gas are called the three states of matter. Most substances exist in all the three states under different conditions. Ice, water and steam are the three states of the same matter under different conditions. Water exists as ice in the solid state and as steam in the gaseous state. The change of state takes place when heat is provided or withdrawn as shown:

$$\text{ice} \xrightarrow[\text{(heat)}]{} \text{water} \xrightarrow[\text{(heat)}]{} \text{steam} \xrightarrow[\text{(cool)}]{} \text{water} \xrightarrow[\text{(cool)}]{} \text{ice}$$

VAPOUR AND GAS

There is a slight difference between the terms "vapour" and "gas" as used by scientists. When a gas exists in presence of the liquid of the same substance under the same conditions of temperature and pressure, the gaseous state is called vapour.

We shall later investigate about special temperatures at which these changes from one state to another take place.

VOLUME

Most of the substances around us exist in the solid state. A piece of stone, book, table and objects made of iron or aluminium that we see around are all examples of solids. Do these objects always have the same shape and volume? What would happen if a piece of stone is hammered?

Activity 2. Take a graduated cylinder. Fill it partly with water and read off on the scale the volume of water. Tie a piece of stone with a string and lower it into the water so that the stone is fully below the water level. Read off the scale of the graduated cylinder, which gives the total volume of water and the piece of stone. Difference between the two readings gives the volume of the piece of stone.

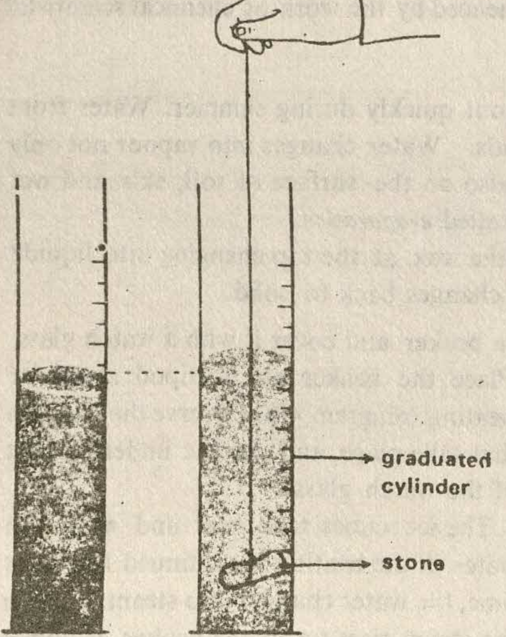


Diagram 41

Now repeat the experiment after hammering the stone into two or three large pieces. Also find the volume of a piece of iron similarly.

You will notice that normally solids keep their own shape. The shape of solids changes due to application of force; but, the volume remains unchanged.

Activity 3. Pour some water into a graduated cylinder. Now transfer the water into a ***reagent bottle***, a saucepan, a flask. How does the shape of the water change?

While the volume of a liquid remains the same, its shape changes according to the container it is put in. An important property of a liquid that you would have noticed is that it "flows".

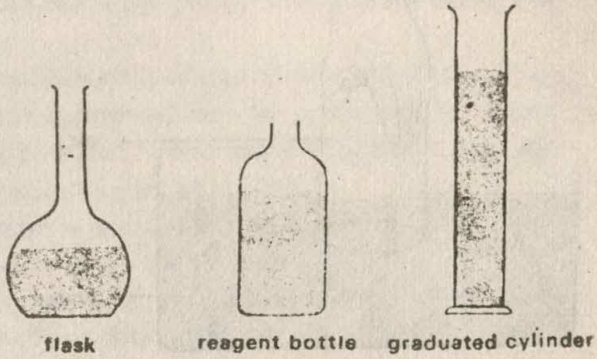
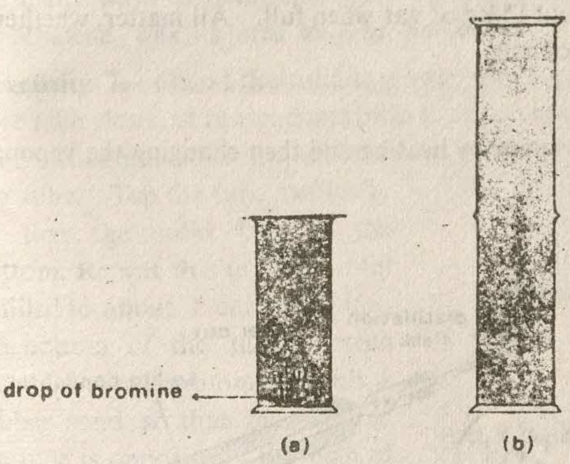

flask reagent bottle graduated cylinder

Diagram 42

Activity 4. Take a drop of liquid ***bromine*** in a gas jar. Cover the jar with a greased glass plate and leave it for some time (diagram 43*a*). Now remove the glass plate and at once cover the jar with another one, mouth to mouth, as shown in diagram 43*b*. What do you notice in the two gas jars?

Bromine is a ***volatile*** liquid; it changes to gaseous state at room temperature and fills the first jar and then both the jars completely. Gases occupy space but they have neither a definite shape nor a definite volume. If the top jar is removed, the bromine gas would spread out throughout the room and beyond.



(a) (b)

Diagram 43

Gases also have the property of "flow". Liquids and gases are therefore called ***fluids***.

Activity 5. Fill a trough with water and push an empty beaker with mouth downwards into the water. You will observe that water does not completely fill up the beaker because the beaker is not empty but full of air. However, the volume of air does seem to decrease slightly (diagram 44).

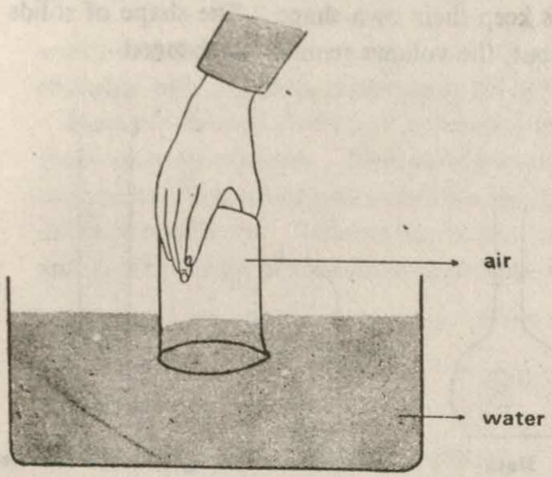


Diagram 44

When the beaker is pushed into the trough with its mouth slightly tilted upwards, the air bubbles out of the beaker and water takes its place.

MASS

The stuff contained in a substance has a property of mass which shows how much and how well packed the stuff is in the substance. A log of wood contains a lot of matter, and has a greater mass, as compared to a piece of stone. It is difficult to lift a bucket full of water because of the large mass of water which has a lot of weight.

A car or scooter tyre filled with air is much heavier than when flat. Gas cylinders used for cooking at home contain about 15 kg of gas when full. All matter, whether solid, liquid or gas, has mass and volume.

BOILING POINT

The process of changing a liquid to vapour by heating and then changing the vapour back to liquid by cooling is called ***distillation.*** The liquid thus collected separately in a receiver is called the ***distillate.*** A ***Liebig condenser*** (diagram 45) is used to obtain the distillate.

Activity 6. Take about 100 cm^3 of water in a distillation flask and connect a Liebig condenser to the flask. Let a steady stream of cold water from a tap enter the lower inlet of the condenser as shown in the diagram. Fix a thermometer in the flask such that the bulb of the thermometer is near the outlet of the flask. Now heat the flask from below and note the temperature every half minute for a few minutes. Does the temperature keep on rising indefinitely? At what temperature does the water begin to boil?

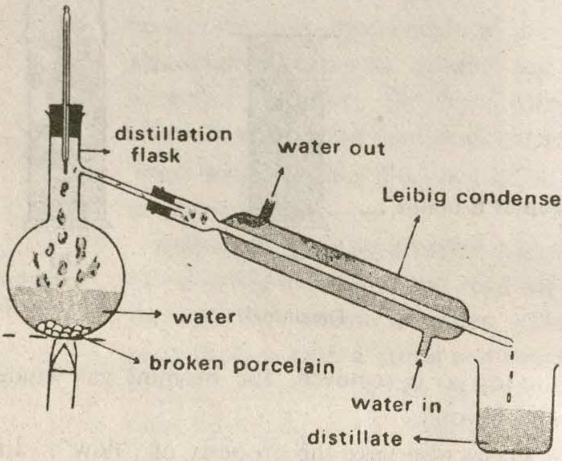


Diagram 45

You will notice that in spite of continued heating, the temperature remains constant when water is constantly changing into steam. *This constant temperature at which water changes to steam its gaseous state is called its boiling point.* Bumping takes place when water starts boiling; to avoid this, a few pieces of broken porcelain may be added to water.

Now add about 50 g of sugar to 100 cm^3 of water and repeat the experiment. Does the boiling point remain constant? The experiment may be performed by adding other substances such as common salt to water. How can you find out from the experiment whether a given sample of water is pure or impure?

You find that the boiling point of water is raised when impurities are added to it. The boiling point of pure (distilled) water at normal pressure (when at sea level) is taken as 100°C. A pure liquid has its own fixed boiling point at normal pressure, a property which can be used for identifying that liquid.

MELTING POINT

Melting point is that temperature at which a solid changes into its liquid state. There are many ways of determining the melting point of solids. The melting point of naphthalene, wax or urea may be found out as follows.

Activity 7. Grind the solid to power with a pestle in a mortar. Take a narrow bore tube closed at one end and push the open end of the tube through the powdered solid until some solid has entered the tube. Tap the tube vertically so that the solid falls to the bottom. Repeat this until the solid is filled to about 1 cm height into the bottom of the tube. Attach the tube to a thermometer with a rubber band so that the solid in the tube is opposite to the bulb of the thermometer. (Why?)

Place this tube into a boiling tube containing either water or liquid paraffin. Ensure that the open end of the narrow tube and the rubber band are well above the level of the liquid in the boiling tube. Now heat the liquid slowly using a burner with a small flame under a wire gauze. Stir the liquid constantly. Remove the burner as soon as you see a contraction of the solid.

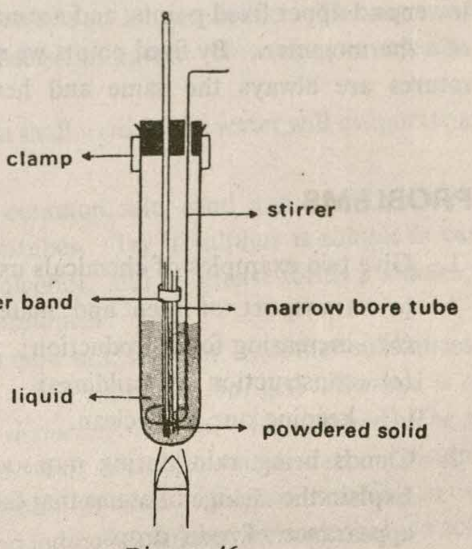


Diagram 46

You will notice that the solid changes to liquid at this temperature; this is its melting point. Compare your result with those of other students. Do you all get the same results? How will you know whether the solid is pure or impure?

The thermometer records the same temperature as that of the solid when its bull is held very close to the solid. Also, in order to find out the exact melting point, the temperature change near the melting point should be gradual. The solid is therefore heated indirectly. When should water and when should liquid paraffin be taken in the boiling tube?

The liquid in the boiling tube should have its boiling much higher than the melting point of the solid. For solids whose melting point is below 100°C, water could be taken in the boiling tube; if the melting point of a solid is not much above 100°C, liquid paraffin could be taken in the boiling tube.

When experimental results of the boiling point and melting point are compared with those mentioned in books, you may find that they are not identical. This could be due to manufacturing defects of thermometers or slight inaccuracies in observations.

Pure solids have a sharp melting point; impure solids melt over a wide range of temperature. The temperature at which any pure solid melts is characteristic of the solid and hence can be used for identifying it. Pure ice melts at 0°C. The temperatures of pure melting ice and of steam above boiling water at sea level are called the lower and upper fixed points, and are marked as 0°C and 100°C on the *Celcius scale* of a thermometer. By fixed points we mean that under given conditions the temperatures are always the same and hence reproducible.

PROBLEMS

1. Give two examples of chemicals used in each of the following:
   (*a*) transport of men and materials;
   (*b*) increasing food production;
   (*c*) construction of buildings;
   (*d*) keeping our body clean.
2. Clouds bring rain during monsoon. Where do all the clouds come from? Explain the change of states that take place from the formation of clouds to the appearance of rain drops.
3. There are two main ways in which water on the ground after the rains disappears. Explain.
4. What would happen if in the Liebig condenser the stream of cold water passes from the tap downwards instead of entering from the lower inlet?

8

Separation of Substances from a Mixture

If a bagful of coins containing 5, 10 and 25 paise coins is spread out in front of you, it would be an easy matter to separate them out in three different piles, each pile containing coins of the same value. It would be equally easy to separate out marbles and stones from a mixed pile. Quite often chemists are faced with a problem of separation of substances when the difference between the substances is not so obvious, and hence the separation is not easy. Let us study some of the simple methods they use in the separation of substances present in a ***mixture***.

SOLUTIONS

Activity 1. Add a little sugar to water in a test-tube and shake well. Can you see the solid particles of sugar now? Taste the liquid formed.

The liquid formed tastes sweet. Clearly the sugar is present in every portion of the liquid. It appears that the bigger solid particles of sugar have been broken up into a large number of very small particles which are no longer visible. The sugar is said to be ***soluble*** in the water; or, the sugar ***dissolves*** in water. Now can you separate the sugar from water?

If the liquid is allowed to dry in an open shallow dish, the water will evaporate away leaving behind the sugar in solid form.

Activity 2. Add small amounts of common salt, sand and chalk to separate portions of water taken in different test-tubes. Try if sulphur is soluble in carbon disulphide, whether iodine dissolves in alcohol, and if grease forms a ***solution*** with petrol. Does water dissolve these substances?

You will observe that except for common salt, none of the other substances mix with water and are said to be ***insoluble***. *The substance that gets dissolved is called **a solute**, and the substance that does the dissolving is known as a **solvent**. The solute dissolves in a solvent to form a solution.* For example, water, carbon disulphide, alcohol and petrol are solvents used in the above cases. Sulphur is soluble in carbon disulphide, grease dissolves in petrol, and iodine is a solute where alcohol is a solvent.

SEPARATION OF SOLIDS IN A MIXTURE

The method of forming solutions is very commonly employed in the separation of substances.

Activity 3. Mix small amounts of common salt, powdered sulphur and sand.

Observe the mixture through a magnifying glass (hand lens); you can clearly see three different kinds of particles in the mixture. How could these be separated?

Put about 5 g of the mixture into a beaker. Half fill the beaker with water and stir well. Now fold a ***filter paper*** twice to form a cone (see diagram 47*a*). Fit the filter paper into a glass funnel. Wet it with a few drops of water so that it sticks to the funnel. Now using a glass rod pour the liquid through the filter. Take care that the liquid does not reach to the very top of the filter paper. (Why?)

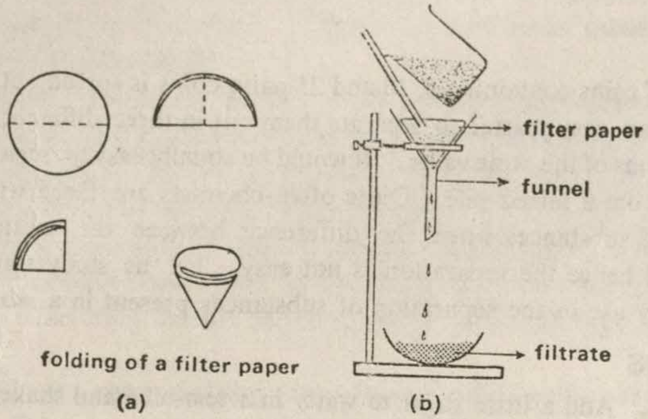


Diagram 47

The liquid that passes through the paper is called the ***filtrate***. Taste it and keep it on an ***evaporation dish*** (diagram 48). The filtrate is a solution of common salt in water. What has happened to the sand and sulphur in the mixture?

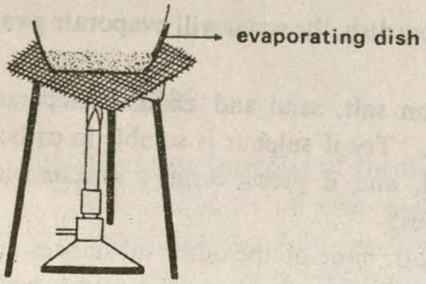


Diagram 48

You will notice that most of the sand remains in the beaker while tiny particles of sulphur and sand in ***suspension*** are retained on the filter paper. Is the mixture free of salt? How could you find out?

Add some water to the mixture left in the beaker, allow the particles to settle down and filter again. The filtrate is still salty showing that salt was present in the mixture. Repeat the process at least three times; we say that the mixture has been "washed by ***decantation***."

Heat all the salt solution collected in the evaporating dish on tripod and gauze. When the solution is almost dry, the hot solution and solid particles of salt jump out of the dish; hence use a small flame. Continue heating until dry salt is obtained. Most of the common salt we consume in our food is obtained by a process of drying of sea water on shallow plots of land near the seashore.

Transfer the sulphur and sand left on the filter paper to the test-tube and dry the mixture by careful heating of the tube above a flame. Now cool it, add some carbon disulphide and shake the tube. The sulphur alone will dissolve while the sand will not. Filter and take a few drops of the filtrate on a clean microscope slide. Carbon disulphide is a volatile liquid and will evaporate quickly leaving a yellow deposit of sulphur. If a ***microscope*** is used to observe the sulphur, its small particles will be seen to have a definite shape with sharp edges. Such regular formation of solids is called a ***crystal***.

SEPARATION BY SUBLIMATION

Activity 4. Put a small quantity of ammonium chloride into a dry test-tube and heat it. What do you observe? Now mix some common salt and ammonium chloride, and heat the mixture strongly in a dry test-tube. What do you notice?

Ammonium chloride changes directly from solid to gas on heating, and back to solid on cooling, without changing to the intermediate liquid state. Such substances are said to ***sublime***; the solid deposited on cooling is called a ***sublimate***. When mixed with a substance such as common salt, sublimation can be a useful method of separation of a substance that sublimes.

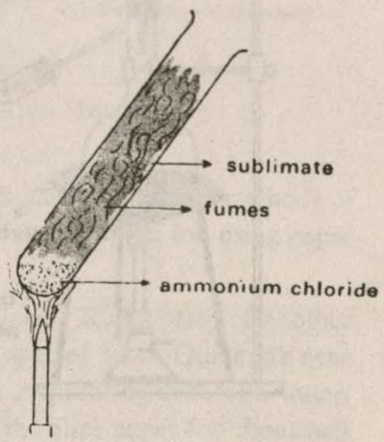


Diagram 49

SEPARATION OF IMMISCIBLE LIQUIDS

Activity 5. Put approximately 5 cm^3 of carbon disulphide and 20 cm^3 of water into a beaker. You will notice that the liquids form two layers and are said to be ***immiscible***. Water, which is less dense of the two, lies on the top. How can the two liquids be separated?

Transfer them to a ***separating funnel***. Hold the funnel vertically, remove the stopper and run the heavier carbon disulphide into a receiver (diagram 50). Stop the flow of carbon disulphide when the line dividing the two liquids reaches the hole of the tap. Collect the water left into another receiver.

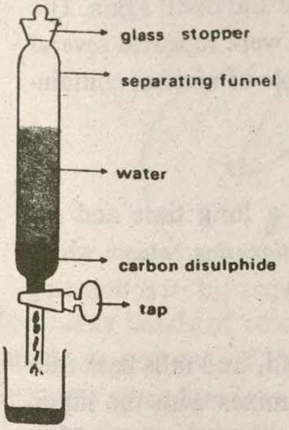


Diagram 50

SEPARATION OF MISCIBLE LIQUIDS

Liquids which mix with each other are called miscible liquids. Alcohol and water

are completely miscible. How can this mixture of the two liquids be separated again?

Alcohol boils at 78.5°C and water boils at 100°C. What will happen if a mixture of the two liquids is heated in a distillation flask?

Activity 6. Half fill a distillation flask with the mixture of alcohol and water. Add a few pieces of broken porcelain. (Why?) Heat the mixture gently. Heating causes evaporation of both the liquids; hence, the distillate collected at about 80°C will contain all the alcohol in the mixture and a little water.

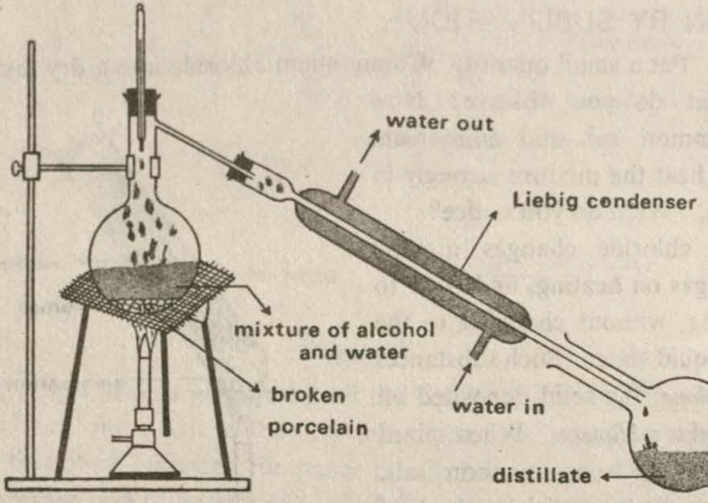


Diagram 51

Throw away the liquid left in the flask, fill it with the distillate and distil again. The distillate collected now will be richer in alcohol. If the process were repeated several times, the distillate finally obtained at about 80°C will be a sample of alcohol containing very little water.

FRACTIONAL DISTILLATION

Collecting the distillate and re-distilling several times takes a long time and the process is rather tedious. This can be avoided by using a ***fractionating column*** which gives the effect of several distillations. There are many types of fractionating columns of which one is shown in the diagram 52.

The vapour rises up the column, cools and condenses to liquid, and falls back into the flask. The hot vapour going up the column meets and mixes with the liquid falling down. A portion of the liquid falling down changes to vapour again. Thus the change of liquid to vapour, and the vapour changing back to liquid, takes place several times in the column. This gives the effect of several distillations and the vapour which finally enters the condenser contains the liquid with the lowest boiling point. Thus almost pure alcohol can be obtained from ***aqueous*** alcohol.

The separation of two or more miscible liquids by distillation making use of the difference in their boiling points is called fractional distillation. The distillate is collected in fractions at different temperatures. Fractional distillation is widely applied in industry to purify and separate liquids. Crude petroleum, a black oily liquid obtained from the earth gives several fractions, e.g., petrol, kerosene, diesel oil, fuel oil and lubricating oil.

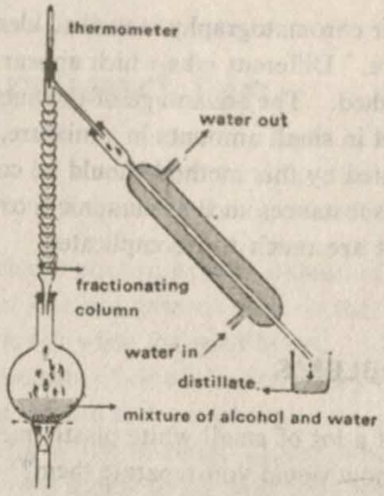


Diagram 52

CHROMATOGRAPHY

Chromatography means "colour writing". Although there are many methods of chromatography, a simple method of separation of different dyes in ink using paper is described below.

Activity 7. Make a hole in the centre of a filter paper. Roll a strip of another filter paper and put it into the hole. Put a very small spot of black Quink ink near the hole and leave it to dry. Half fill a ***petri dish*** or an evaporating dish with water. Place the filter paper on the evaporating dish. Leave the filter paper for about half an hour. Then remove the paper carefully and allow it to dry.

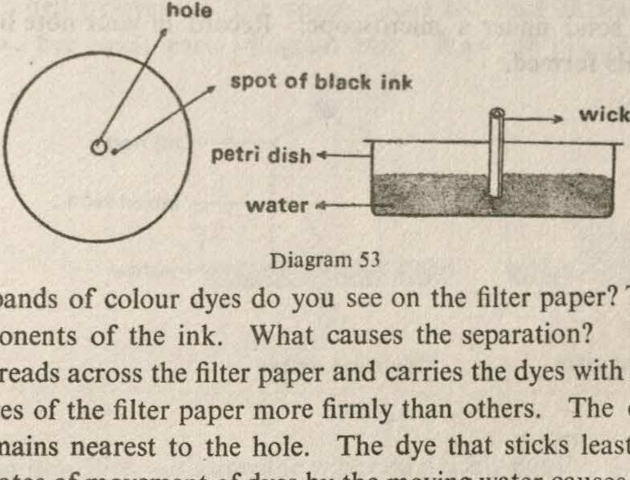


Diagram 53

How many bands of colour dyes do you see on the filter paper? These show the coloured components of the ink. What causes the separation?

The water spreads across the filter paper and carries the dyes with it. Some dyes stick to the fibres of the filter paper more firmly than others. The dye that sticks most firmly remains nearest to the hole. The dye that sticks least goes furthest. Thus different rates of movement of dyes by the moving water causes the separation. This method of separation is called paper chromatography.

Paper chromatography is used to identify simple substances present in a complex mixture. Different inks which appear alike when used for writing can also be distinguished. The advantage of this method is that it separates substances which are present in small amounts in a mixture. It is not essential that the substances to be separated by this method should be coloured; also, instead of paper, thin layers of other substances such as aluminium oxide or silica gel are often used but these techniques are much too complicated.

PROBLEMS

1. If a lot of small white plastic pieces appear to be mixed in a sample of sugar, how would you separate them?
2. Give an example to explain the meaning of solute, solvent and solution.
3. How can you show that there is always some air dissolved in water?
4. In many town water supply systems, chlorine gas is dissolved in the water supplied for drinking purposes. Find out how and why this is done?
5. Match the following:
   Solute: common salt, sulphur, grease, iodine.
   Solvent: carbon bisulphide, petrol, water, alcohol.
6. Dissolve some copper sulphate powder in a small quantity of water. Gradually warm the solution on an evaporating dish or a few drops of it on a microscope slide. When all the water is evaporated and the blue solid appears again, observe the solid under a microscope. Record in your note book the shape of the crystals formed.

9

The Air Around Us

Our earth is surrounded by a layer of air which extends to a height (***altitude***) of several thousand metres. Although it is transparent and in a gaseous state so that we can easily see and walk through it, its presence is felt when the wind blows. Kites and birds fly as high as air takes them and the movement of clouds is directed by winds in the upper ***atmosphere***. A very immediate importance and use of air to us is in breathing. Without air we cannot survive even for a few minutes. There is no air on the moon and astronauts have to carry their own supply of air with them when they land on moon; even mountaineers, when they climbed Everest had to carry their supply of air because at that altitude there is very little air. Air dissolved in water is essential for the survival of fish.

BURNING IN AIR

Activity 1. Light a candle and place it on the table. Now cover it with a jar. You will notice that it blows out within a few minutes. Thus burning also requires the presence of air. Since burning of chemicals is our main source of energy, air is vital to us. Let us study what is the chemical that plays such an important part in burning.

Activity 2. Float an evaporating dish containing white ***phosphorus*** in a trough of water and place a bell jar over it. The space above the level of water in the bell jar is divided into five equal parts (diagram 54*a*). Burn the phosphorus by touching it with a long iron wire, withdraw the wire and quickly put the stopper on the bell jar The phosphorus burns with a yellow flame giving off dense white fumes. While the

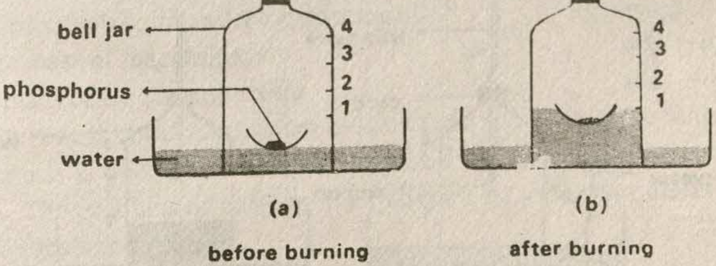


Diagram 54

phosphorus is burning, you may notice that the level of water inside the bell jar goes down slightly.

After some time the burning stops. Note the level of water in the jar at the end of the experiment. The level of the water inside the jar rises to the first mark (diagram 54*b*). Remove the stopper of the bell jar and quickly introduce a lighted splint into it. The splint is extinguished. Why? The white fumes disappear after some time. What could be these white fumes and where do they disappear?

When phosphorus burns, the heat produced causes expansion of air; hence, the level of water falls in the beginning. When the air gradually cools down, the level rises to one-fifth of air volume in the jar. This suggests that air consists of one-fifth by volume of a gas which supports burning.

OXYGEN

When the active part of air is used up in burning, water takes its place. Now when a lighted splint was introduced into the residual air, which is four-fifth by volume, the splint is extinguished; this residual part of air, therefore, does not support burning. Thus, air contains at least two gases. The part of air which supports burning is called ***oxygen***; the part of air which does not support burning mainly contains ***nitrogen.***

The white fumes show a new substance formed by the combination of phosphorus with oxygen of the air. This is called phosphorus oxide, more correctly phosphorus pentoxide. We write this ***reaction*** in the following way:

phosphorus + oxygen = phosphorus pentoxide

The fumes of phosphorus pentoxide disappear by dissolving in water.

BURNING OF MAGNESIUM IN AIR

Activity 3. Place a bell jar in a trough containing water. Mark off the space above the level in the jar into five equal parts. Tie a magnesium ribbon to an iron wire and light it. Quickly introduce the burning ribbon into the bell jar and replace the cork. Record what you observe. After some time introduce a burning splint into the bell jar to find out if the residual air supports burning.

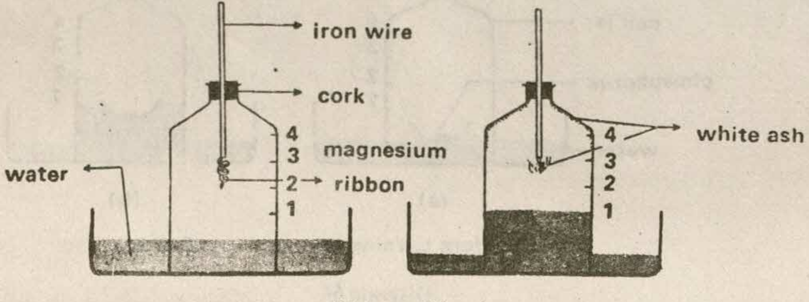


Diagram 55

You will notice that magnesium burns with a blinding white light and forms a white ash while the level of water rises to one-fifth. The residual part does not support the burning of a splint.

Like phosphorus, magnesium also combines with the active part of air called oxygen, leaving four-fifth part which is inactive. The white ash is a new substance formed by the combination of magnesium with the oxygen in the air and is called magnesium oxide.

magnesium + oxygen = magnesium oxide

Similar experiments show that when substances burn in air they combine with oxygen present in the air.

CHANGE OF MASS DURING BURNING

Activity 4. Weigh a clean and dry crucible with the lid. Put about 10 cm long folded magnesium ribbon in the crucible, cover it with the lid and weigh again. Remove the lid and heat the crucible strongly. When magnesium begins to burn, cover the crucible with the lid. Raise the lid slightly so as to allow the air to enter but ensure that the white particles of magnesium oxide do not go out of the crucible. Cover the crucible with the lid and cool it in a ***desiccator***. (Why?) Weigh the crucible containing magnesium oxide with the lid. You have taken three weights.

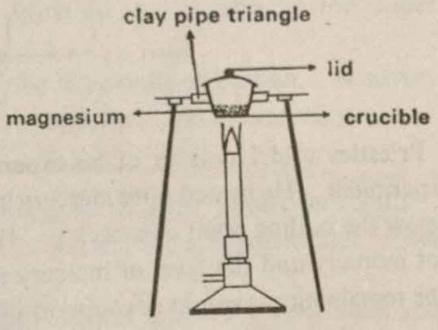


Diagram 56

1. Mass of crucible with lid $= a$ g (say)
2. Mass of crucible, lid and magnesium $= b$ g
3. Mass of crucible, lid and magnesium oxide $= c$ g

Hence, the mass of magnesium $= (b - a)$ g

And, the mass of magnesium oxide $= (c - a)$ g

You will notice that the magnesium oxide weighs more than the magnesium. The increase in mass is due to the mass of oxygen of the air which has combined with magnesium. The products of burning in air contain a greater amount of matter than the original substance.

A MILESTONE IN SCIENTIFIC ENQUIRY

Burning of substances was known for a long time; with fire man was able for the first time to cook his food, keep himself warm on cold nights, make new tools and weapons. It was an important milestone in the history of human progress. But the scientific explanation of burning was first given after systematic and careful experiments carried out by Joseph Priestley (1774) and Antoine Lavoisier (1779).

Priestley performed his classical experiment in which he heated red mercury oxide by focussing sun rays on it using a magnifying lens. A modified Priestley's apparatus is shown in diagram 57. He collected a colourless gas which burned a candle more brightly and a mouse lived longer in the gas than it would live in the same quantity of normal air. What was this gas?

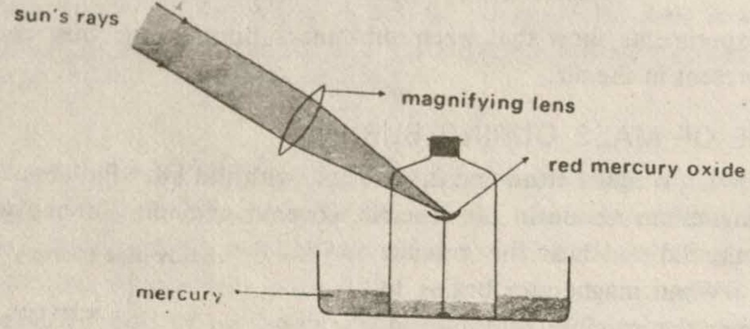


Diagram 57

Priestley told Lavoisier of his experiment who carried out his classic twelve-day experiment. He heated pure mercury in a ***retort*** for twelve days at a temperature just below the boiling point of mercury. He noticed a red powder on the surface of the hot mercury and the level of mercury rose to one-fifth in the bell jar (diagram 58). The remaining gas would not support life or burning. What was the residual gas?

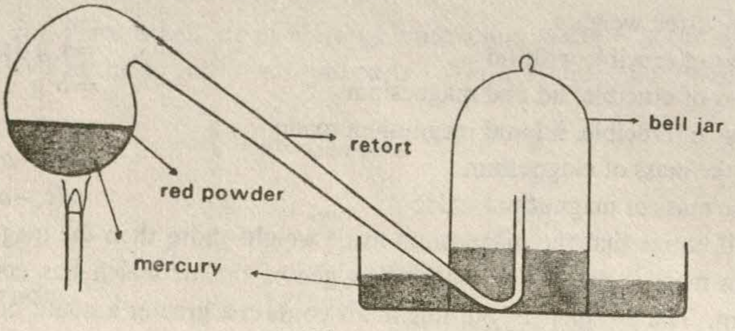


Diagram 58

Lavoisier collected the red powder carefully and heated it strongly. He obtained mercury and "Priestley's gas", which caused a glowing splint to burn brightly and in which small creatures were active. Lavoisier named this gas oxygen. The residual four-fifth gas which does not support burning is mostly nitrogen. The changes which took place in Priestley's and Lavoisier's experiments are as follows:

$$\text{Mercury oxide} \xrightarrow[\text{(strong heating)}]{} \text{mercury} + \text{oxygen}$$

$$\text{mercury} + \text{oxygen} \xrightarrow[\text{(heating in air)}]{} \text{mercury oxide}$$

Priestley's and Lavoisier's experiments show us the scientific method of finding out the nature of unknown substances and phenomena. Their work provides an example of scientific enquiry and cooperation among scientists; it is therefore an important milestone in scientific progress.

DECOMPOSITION AND SYNTHESIS

Breaking up of a substance into two or more substances is called ***decomposition***. In the above case, mercury oxide decomposes into mercury and oxygen on strong heating. Building up of a substance from two or more substances is called ***synthesis***, as in the formation of mercury oxide from mercury and oxygen.

Activity 5. Heat some red mercury oxide in a test tube. After a few minutes, introduce a glowing splint into the test tube. What do you observe on the upper part of the test tube?

The glowing splint is rekindled, indicating the liberation of oxygen. A silvery white solid is deposited on the upper part of the test tube. This is mercury.

WATER VAPOUR IN AIR

In the upper atmosphere air carries clouds which give us rain; ponds, wet clothes, etc. are always drying out due to evaporation of water. This suggests that water vapour is always present in the air around us.

Activity 6. Place a glass of water with a few pieces of ice in it on the table and cover it with a lid. Within a few minutes you will oberve tiny drops of a colourless liquid on the outside of the glass. Where could these drops of colourless liquid have come from?

Prepare a solution of ***cobalt chloride*** in water. The colour of the solution is pink. Dip a strip of filter paper in the solution and dry the strip by keeping it well over a bunsen flame. Do you notice any change in colour? Put a drop of water on the dry strip of paper. Do you observe any change?

Dry cobalt chloride is blue in colour. When drops of water fall on the cobalt chloride paper, it turns pink. The dry cobalt chloride paper can, therefore, be used for testing the presence of water.

Touch a dry cobalt chloride paper to the drops of liquid on the outside of the glass. The paper turns from blue to pink showing that the liquid is water. The water was formed by condensation of vapour present in the atmosphere due to the very low temperature outside the glass. The early morning dew which we see on the ground and on leaves during winter is formed in a similar way.

CARBON DIOXIDE

Is the air we breathe in different in any way from the air we breathe out?

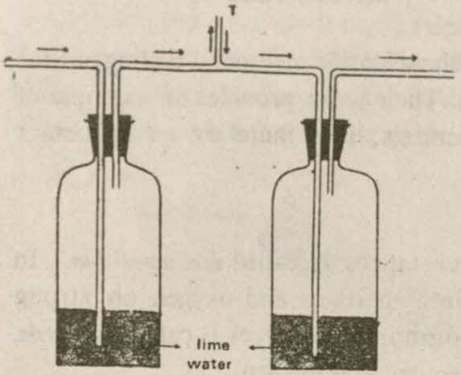


Diagram 59

Activity 7. Take some ***lime water*** in two bottles fitted with rubber stoppers These are fitted to an apparatus shown in diagram 59, so that if you suck in through the tube T, the air enters through one bottle; and when you breathe out, the air goes out through another bottle. Now suck in and out for a few times. Both the bottles with lime water in them are kept side by side for comparison. Notice any difference in the two samples.

You will observe that the lime water through which the ***exhaled*** air is passed forms a milky suspension. This is due to a gas called ***carbon dioxide.***

Actually, some carbon dioxide is present in the air we ***inhale*** because we are all the time breathing out the gas. However, it is present in such a small quantity that the above experiment will have to be continued for almost half an hour before lime water in the first bottle also turns sufficiently milky to be clearly seen.

NOBLE GASES

Besides oxygen, nitrogen, carbon dioxide and water vapour, there are other gases present in very small quantity in the air around us. There are six noble gases. Five of them—helium, neon, argon, krypton and xenon—are present in air. The sixth noble gas, radon, is obtained by the decomposition of radium. These gases are generally very inactive, *i.e.* they hardly react with other chemicals; hence, they are called inert or Noble gases.

Careful measurements show that the approximate composition of air, by volume, is as follows:

Nitrogen — 78.03 %
Oxygen — 20.99 %
Carbon dioxide — 0.03 %
Noble gases — 0.95 %
Water vapour and other gases—in small traces

While the composition of the gases is generally constant everywhere in the earth's atmosphere, the percentage content of water vapour varies considerably from place to place. Nitrogen, the most abundant of all gases, has not been very much studied so far because it does not easily take part in reactions. One use of the nitrogen is, however, obvious; if all air were to contain mostly oxygen, even small fires would turn into huge explosions and cause great damage. The large proportion of an inactive gas like nitrogen therefore keeps fires under control. Nitrogen is needed by all living things and we shall see later how we obtain our supply of nitrogen from the atmosphere. Carbon dioxide is required by plants. The role of Noble gases is not yet known, but they are in any case present in very small quantity in the atmosphere.

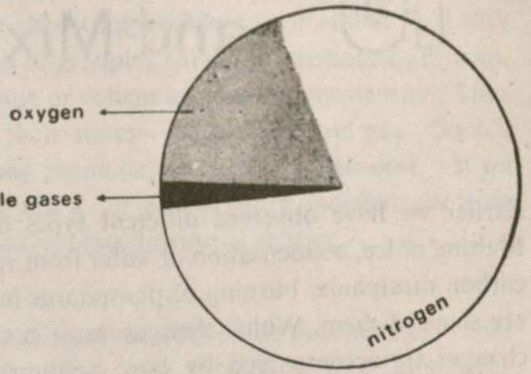


Diagram 60

POLLUTION OF THE AIR

Air, particularly in industrial towns, gets polluted with traces of other substances. Burning of coal produces harmful gases like carbon monoxide and sulphur dioxide. It also produces large quantities of unburnt carbon, tarry matter and fine dust particles. Incomplete combustion of petrol and diesel in car engines produces carbon monoxide. Most of these substances are harmful to human beings and to the growth of plants. Enough efforts are not being made in our country to minimise air pollution.

PROBLEMS

1. Describe experiments to show that oxygen is essential for burning and breathing. What do you expect to happen if a living insect is placed in a jar which is filled with oxygen only?
2. You are told that Carbon dioxide and water are formed when a candle burns in air. How you would conduct experiments to identify these products?
3. Why is breathing considered to be a process similar to burning?
4. Write a report on the causes of the pollution of air and the harm it causes to health.
5. Describe experiments to show the difference between synthesis and decomposition.
6. Why is phosphorus kept under water?
7. Why should the crucible containing hot magnesium oxide be cooled in a desiccator?

10

Elements, Compounds and Mixtures

Earlier we have observed different types of changes taking place in substances. Melting of ice, condensation of water from vapour or steam, dissolving of sulphur in carbon disulphide, burning of phosphorus in air, and burning of magnesium in air are some of them. Which changes result in the formation of new substances? Which changes are accompanied by large amount of energy changes (for example, heat given out or heat absorbed)? In which cases is it possible to get back the orginal substances easily?

PHYSICAL AND CHEMICAL CHANGES

Melting of ice results in the formation of water which is a liquid state of the same substance; the change involves slight heating and the water can be changed back into ice without great difficulty. As the sun rises and the day gets warmer, mist and dew quickly disappear as vapour again. Dissolving of a solute in a solvent also produces no new kind of substance; the solid solute can be easily separated from the solvent by evaporation. If we carry out weighings in the above experiments, we would find no change of weight in the substances which have undergone these changes. Such changes are called ***physical changes.***

On the other hand, burning of phosphorus or magnesium in air forms new substances which cannot be changed back easily into the original substances. Heat and light energy are both liberated in the burning of these substances, and the products show an increase in mass as compared to the mass of original substances. Such changes are called ***chemical changes.***

These simple characteristics of physical and chemical change may be summarised as below:

Physical change	*Chemical change*
1. No new substance is formed. (Melting of ice, boiling)	1. New substances are formed. (Phosphorus + oxygen = Phosphorus pentoxide)
2. Usually energy change is small. (Dissolving of sugar in water)	2. Often energy change is large. (Burning of magnesium in air)
3. Can be easily reversed. (Condensation of steam)	3. Cannot be easily reversed. (Magnesium oxide decomposition)
4. There is no change of mass. (Melting of ice)	4. Product masses are different. (Burning of phosphorous in air)

Millions of different materials and chemicals exist in the world. Scientists are always adding to this list. It would be almost impossible to remember how they behave, look and feel unless we find ways of grouping them into distinct categories. We know all gases flow, have no fixed shape or volume and have a low density. Thus one method of grouping is according to their states—solid, liquid and gas. Such a grouping of substances, according to some properties, is called ***classification.*** If we study one member of a group we can tell a lot about other members of that group. Let us consider one other method of classification of matter.

ELEMENTS

Activity 1. You have seen that the heating of mercury oxide decomposes it into simpler substances—mercury and oxygen. Heat a few crystals of lead nitrate in a test tube; introduce a glowing splint into the test tube. What happens to the splint? Do you notice any other gas? What is the colour of the residue left in the test tube?

The crystals of lead nitrate produce oxygen which rekindles a glowing splint. A brown gas is also given off and a yellow coloured residue is left in the test tube.

Copper carbonate is green in colour. If a small amount of the chemical is heated, it gives out carbon dioxide gas which turns lime water milky and a black residue is left in the test tube.

Both lead nitrate and copper carbonate decompose into simpler substances by heating. However, not all chemicals break down easily into simpler substances. When crystals of common salt are heated, they break into smaller particles producing a crackling sound; this is called ***decrepitation.*** But there is no visible sign of the substance breaking down into simpler substances.

Most substances can be broken down into simpler substances either by heating or by more complicated methods which are beyond the scope of this book. A small number of substances, however, cannot be broken down by chemical changes into simpler substances. These substances are called ***elements.***

At present 103 elements are known to exist. Of these, 92 occur naturally on the earth and in the atmosphere, while 11 have been made by artificial means. These elements are the building blocks of all the millions of complicated substances. The most common elements which combine to form the majority of substances are carbon, oxygen, hydrogen and nitrogen. Other elements form only a limited number of substances.

CLASSIFICATION OF ELEMENTS

Carbon, sulphur, sodium, copper, aluminium, magnesium and lead are some of the common elements whose pieces should be available in your laboratory. Let us try classifying these elements according to some physical and chemical properties.

Activity 2. Take large quantities of these elements, except sodium, and put them in increasing order of density. You can estimate the volume and mass of a piece of each element to find its approximate density.

Hit each of these pieces with a hammer. Which of them can be broken up easily into smaller pieces?

Hold one end of carbon, copper, aluminium and lead in your hand and put the other end in a Bunsen burner flame. By comparing the time taken for the other end in your hand to become hot, you can classify these elements according to the property of conduction of heat.

Take a torch cell, connect two wires of copper to its two ends and join their other ends to a torch bulb; the bulb will glow (diagram 61). Now include in turn a small piece of each element and find out if the bulb still glows. Observe and record names of those elements which are ***conductors*** of electricity, *i.e.*, those which let electricity pass through them.

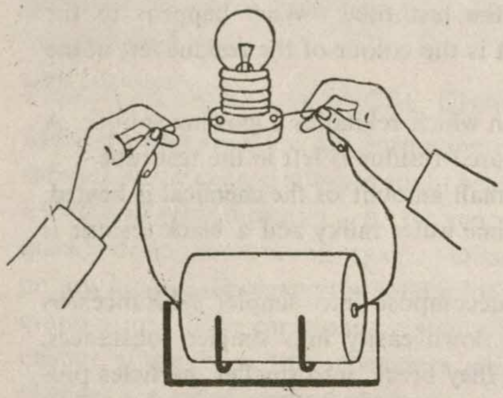


Diagram 61

You will notice that carbon and sulphur have low density. They also have a property called ***brittleness***, *i.e.*, they break into small pieces when hammered with a small force. These two elements do not conduct heat and electricity. (Actually, graphite, a form of carbon, is not such a poor conductor.) Thus, on the basis of some of these physical properties it is possible to classify the elements.

METALS AND NON-METALS

Let us now try to classify these elements on the basis of their chemical properties, *i.e.*, in reactions when chemical changes take place.

Activity 3. Your teacher will get a few jars of oxygen needed for this experiment. (Later on you will learn how to prepare oxygen in the laboratory.) Add about 10 cm^3 of water in a jar containing oxygen and cover the jar. Heat some powdered charcoal (which is a form of carbon) in a ***deflagrating spoon*** until it is red hot. Introduce the spoon into the gas jar and let it remain there until the charcoal stops burning (diagram 62). Remove the deflagrating spoon and shake the gas jar to dissolve the gas formed in water. Add to the water a drop of ***blue litmus solution*** and notice any change of colour.

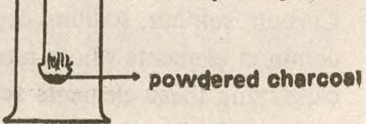


Diagram 62

Take some powdered sulphur in a deflagrating spoon and heat it. When the sulphur starts burning, introduce the spoon into a gas jar containing air. When the sulphur stops burning, remove the spoon and add about 5 cm^3 of water in the jar. Shake well to dissolve the gas formed and add two drops of blue litmus solution. What change do you notice?

In both cases, when the elements burn in oxygen or air, they combine with the oxygen to form oxides; the oxides turn blue litmus solution into red. Elements showing these properties are called ***non-metallic elements.*** The oxides formed by non-metallic elements are called ***acidic oxides.***

Activity 4. Burn a magnesium ribbon by holding it with a pair of tongs. Put the white ash left after burning in about 10 cm^3 of water and boil. Add a drop of red litmus to the solution and note the change in colour.

Sodium should be handled very carefully; your teacher will tell you the precautions needed for handling sodium in the following experiment. Put a very small piece of dry sodium on a piece of broken porcelain and heat it strongly. When sodium starts burning note the colour of the flame. Let the porcelain piece cool and then put it into a beaker containing about 10 cm^3 of water. You will notice that the white residue left on the porcelain dissolves in water. Now add a drop of red litmus and note the change in colour.

Elements like sodium, copper and magnesium are called ***metallic elements.*** Metals have generally high density. They are not brittle but ***malleable***, *i.e.*, they can be hammered into shape, and ***ductile***, *i.e.*, they can be drawn into wires. They are generally good conductors of heat and electricity, and their oxides when dissolved into water turn red litmus blue. Such oxides are called ***basic oxides.*** It may well be remembered that not all metals and non-metals show all the characteristics of the group to which they belong. However, a classification is always useful as a guide.

PROPERTIES OF MATTER

We have already considered some of the properties of matter in the classification of elements. All pure substances possess certain characteristic qualities which have been discovered by scientists and which can be used for the identification of these individual substances. These characteristic qualities of a substance are called properties. They tell the behaviour of a substance and its possible use.

The physical properties are those which can be determined without changing it into a new substance. Colour, density, solubility, melting point, boiling point, electrical and heat conductivity are some of the physical properties. Physical properties are concerned with physical changes. For example, we can know that a colourless liquid is pure water, if it changes to solid state at 0°C and its boiling point is 100°C. In addition, one may find that its density is 1 g/cm^3 and that it is a poor conductor of heat.

The properties of a substance which involve chemical changes are chemical properties. In the study of these properties new substances are formed. Chemical properties are helpful in determining how a substance can be used to prepare other useful substances.

PROPERTIES OF IRON AND SULPHUR

Let us now investigate the properties of two elements—iron and sulphur— of which one is a metal and the other non-metal, separately and in combination.

Activity 5. (*a*) Take some iron dust and powdered sulphur in separate watch glasses and carry out the following experiments on each of them. Note down their colour.

(*b*). Take a little of each in two test tubes and add water. Do they dissolve in water? Repeat with carbon disulphide as a solvent.

(*c*) Hold a bar magnet over each of the two substances in the watch glass and note what you observe.

(*d*) Take each of the two substances separately in two test tubes. Add ***dilute hydrochloric acid*** into the test tube containing iron dust. Close the tube with a finger for a minute and then introduce a lighted splint into the test tube. Do you observe any gas being formed? Note its colour and odour. Repeat the experiment using sulphur.

You will notice that iron is grey while sulphur is yellow. Both are insoluble in water. Sulphur is soluble in carbon disulphide and if you take a few drops of the solution on a microscope slide and allow it to dry, sulphur crystals will be obtained. Iron is attracted by a magnet but sulphur is not (diagram 63).

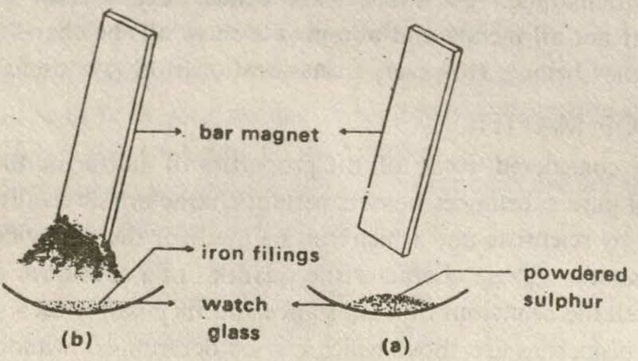


Diagram 63

In the last experiment, when a lighted splint is introduced into the test tube containing iron dust and dilute hydrochloric acid, the splint goes off and there is a "pop" sound produced. This is the property of ***hydrogen gas*** which is colourless and odourless; the gas is produced by a reaction between the two substances. That a gas is being evolved becomes clear from the *effervescence* produced in the test tube. No effervescence is observed in the test tube containing sulphur and dilute hydrochloric acid, and hence no gas is produced.

MIXTURE OF IRON AND SULPHUR

Activity 6. Mix equal amounts of iron dust and powdered sulphur thoroughly on a piece of paper. Is there any change of temperature when the two are mixed?

Examine the *mixture* with a hand lens; can you see the elements separately? What happens when a magnet is held close to the mixture? Take some of the mixture in a test tube and add about 5 cm^3 of carbon disulphide. Shake well and allow the test tube to stand for some time. Now if a few drops of the solution are taken on a microscope slide and evaporated, do you observe any residue left on the slide?

You will notice that iron and sulphur particles exist separately in the mixture. Iron is attracted by the magnet and sulphur still dissolves in the carbon disulphide; in fact, it is easy to separate iron and sulphur.

Activity 7. Take a small sample of the mixture in a test tube and add to it some dilute hydrochloric acid. Test the gas evolved. You will notice that hydrogen gas is produced showing that iron is reacting with the acid.

Thus, both iron and sulphur retain their individual physical and chemical properties in the mixture. They could be mixed in any proportion and no new substance is formed by combining them this way. You also notice no energy change (heat evolved or absorbed) when the mixture is formed; therefore no chemical change takes place.

COMPOUND OF IRON AND SULPHUR

Now let us investigate the properties of a combination of iron and sulphur under different conditions.

Activity 8. Place a little mixture of iron dust and powdered sulphur in a test tube and heat the test tube over a strong flame. When the mixture starts to glow, remove the flame. Does the content of the test tube continue to glow? Allow the test tube to cool and collect the *residue* in a watch glass. Examine it under a hand lens. Do you notice individual particles of iron and sulphur? Apply the test of a magnet to find out whether iron in it is attracted. What do you observe? Take a little portion of the residue and add some carbon disulphide to it. Shake well, allow the particles to settle, and take two drops of the liquid on a microscope slide. When the liquid evaporates, do you see any crystals of sulphur on the slide?

You will notice that individual particles of iron and sulphur are no more visible in the residue. The evaporated carbon disulphide does not leave any sulphur nor is iron from the residue attracted by the magnet. Clearly, individual physical properties of iron and sulphur are no more present; it appears that an altogether new substance has been formed from which iron and sulphur cannot be separated by physical means.

Activity 9. Take another portion of the residue and add dilute hydrochloric acid. Do you see any effervescence? Is the gas evolved odourless? Introduce a strip of paper soaked in ***lead acetate solution*** into the test tube; does the colour of the acetate paper change?

You will notice that effervescence shows that a gas is evolved but it has an unpleasant smell like that of rotten egg. This shows that a new substance is formed by the chemical combination of iron and sulphur. The new substance is called iron sulphide and the chemical reaction is written as follows:

iron + sulphur = iron sulphide

Iron sulphide is a ***compound*** of iron and sulphur and has neither the properties of iron nor of sulphur. During the chemical change much heat is evolved because you see that the red glow of the heated solid continues even though the flame is removed. Such a reaction in which heat energy is given out is called an ***exothermic reaction.***

Taking this example as a typical one, we can now summarise the difference between a mixture and a compound.

Mixture	*Compound*
1. When a mixture is prepared, very little energy change takes place.	1. When a compound is formed, an energy change takes place; usually heat is given out.
2. Formation of a mixture is a physical change.	2. Formation of a compound is a chemical change.
3. Separate particles of the constituents of a mixture can usually be seen.	3. Separate particles of the elements present in a compound cannot be seen.
4. The constituents retain their individual properties. No new substance is formed.	4. The properties of a compound are completely different from those of its component elements. A new substance is formed.
5. The constituents can be separated by physical methods.	5. Physical methods cannot separate the component elements of a compound.
6. The constituents of a mixture need not be mixed in a fixed proportion.	6. The constituents of a compound are in a fixed proprotion. (This fact has not been proved in the above experiments; actually, in any sample of iron sulphide, iron and sulphur are present in a fixed ratio of 7 : 4 by weight.)

IS AIR A MIXTURE OR A COMPOUND?

Once we have classified mixtures and compounds on the basis of certain physical and chemical properties which are present in them, this test can be applied to air to seek answer to the question: Is air a mixture or a compound? Like a scientist, you could ask yourself the following questions:

a. Can the gases present in air be separated by physical methods?
b. Does the composition of air differ from place to place?
c. Are the properties, physical and chemical, of constituent gases present in air?
d. If we mix the gases present in air in right proportions, would there be any energy change that can be noticed?

You have seen that water vapour present in air can be condensed by considerably lowering the temperature. In fact, scientists have cooled air to such a low temperature that it has been changed into its liquid state, and from this the constituent gases such as oxygen and nitrogen have been separated by fractional distillation. Thus, the constituents of air can be separated by physical methods.

While the composition of gases in air is generally constant, slight increase or decrease of a particular gas is always taking place locally. Moreover, the water vapour present in air varies a lot; the climate is more ***humid*** (*i.e.*, there is more water content in air) at places near the sea-shore.

The properties of oxygen, carbon dioxide, water vapour, etc. are present in air. For example, one-fifth of air which is oxygen supports burning. Carbon dioxide retains its property of turning lime water milky even when it is part of air. Water vapour present in air turns cobalt chloride paper from blue to pink. Thus all these constituents maintain their individual characteristic properties while they form part of air.

If the gases are mixed in the proportion in which they are found in air, there is no evolution of heat, emission of light or explosion. Thus, the gases mix together without any chemical change. For these reasons, we can say that air is a mixture and not a compound.

PROBLEMS

1. Describe experiments to show a physical and a chemical change taking place in sulphur.
2. Using iron, sulphur and dilute hydrochloric acid and no other chemical, how would you show the difference between a mixture and a compound experimentally?

3. Several boys carried out an experiment in which they added a piece of sodium to alcohol. Each obtained a gas called hydrogen. They wrote the following conclusions:

   1st boy—alcohol is a compound of hydrogen and something else.
   2nd boy—alcohol contains hydrogen.
   3rd boy—sodium contains hydrogen.
   4th boy—sodium is a mixture of hydrogen and something else.

   Which was the best conclusion and why?

4. What experiments, involving chemical changes, would you perform to show that lithium is a metal and phosphorus is a non-metal?

5. Give three reasons to show that air is a mixture and three reasons to show that water is a compound.

11

The World of Biology

Millions and millions of living things are found in the world. They live in air, on the land and in water. Living creatures include plants and animals ranging from the minutest, which are invisible to the eye, to giant peepul trees and whales. In whatever situation or form we observe them, they give an impression of overwhelming diversity. This tremendous variety provides us with many mysteries to solve and interesting experiments to perform.

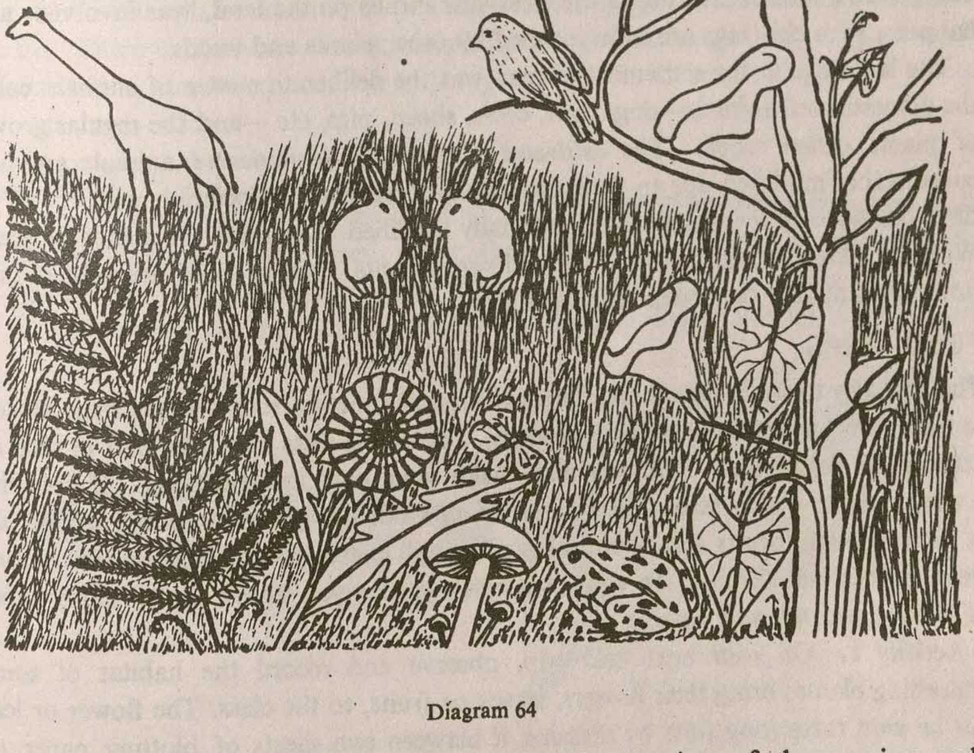


Diagram 64

How is it that flowers have such a magnificent variety of shapes, sizes and colours? What do animals eat for their living? What food do plants eat as they grow bigger and taller? How are diseases caused and what can be done to prevent them? These are some of the problems that interest the biologist. ***Biology is the science of living things.*** Like other sciences, it is not a static science because if some problems are solved, new problems always crop up. Malaria, small pox and other diseases still take their toll of millions of lives every year and the cause of cancer is still an unsolved problem. Aging and life remain a mystery. Soil erosion has not been effectively checked.

ANIMALS AND PLANTS IN OUR LIFE

Early man satisfied his hunger largely by hunting other animals, although he probably added to his diet, fruits, nuts and tubers gathered in the forests. He was himself in constant danger of being attacked by other animals such as lions and crocodiles. Living in groups and the use of implements gave him some protection and safety. His family or tribal group, however, could not protect him from numerous diseases, intestinal worms or body lice.

When man learnt to build shelters, a wide variety of animals—cockroaches, lizards, mice, scorpions, etc.—moved in to share his shelter. With the making of shelters, a new process, that of clearing of the trees and shrubs on the land, was involved; as it happens, such clearings are soon invaded by other plants and weeds.

The last stage in the settlement of man was the deliberate ***taming*** of animals called the domesticated animals—dogs, cats, cows, sheep, pigs, etc.—and the regular growth of plants called crops. The ***cultivated*** plants and ***domesticated*** animals are now considerably modified due to their thousands of years of association with man. In turn, our ways of living have been gradually modified over these thousands of years. With the advent of agriculture, man and some plants such as corn are united in a firm and mutually dependent partnership.

FIELD TRIPS

The best way to study how living things around us function is to observe them closely in their own habitat (natural surroundings). The whole class may take part in such an activity on field trips. You can also make your own investigations. If you visit a zoo, you can watch birds and animals of all kinds not generally found around us. A walk through forests and botanical gardens will enable you to observe fascinating trees, bushes and shrubs. In your own small garden you come across many types of beetles, worms and insects.

Activity 1. On your next field trip, observe and record the habitat of some interesting plants; bring their flowers, leaves or fruits, to the class. The flower or leaf can be kept for a long time by pressing it between two sheets of blotting paper or newspaper; cover it with more sheets of paper and then place some heavy books on top. (Since the paper will absorb water from the plant, you should change it after a day or two.) When the leaf or flower is dry, stick it on a sheet of paper or cardboard. Make a note on the paper of the date of collection, habitat and name (if known) of the plant. Arrange such cards around the classroom or in your home.

Activity 2. Collect some animals such as earthworms, tadpole, flea, cockroach, caterpillar and keep them in the laboratory in jam jars, tins and wooden boxes. Look after them carefully and make daily observations about their food habits and other behaviour.

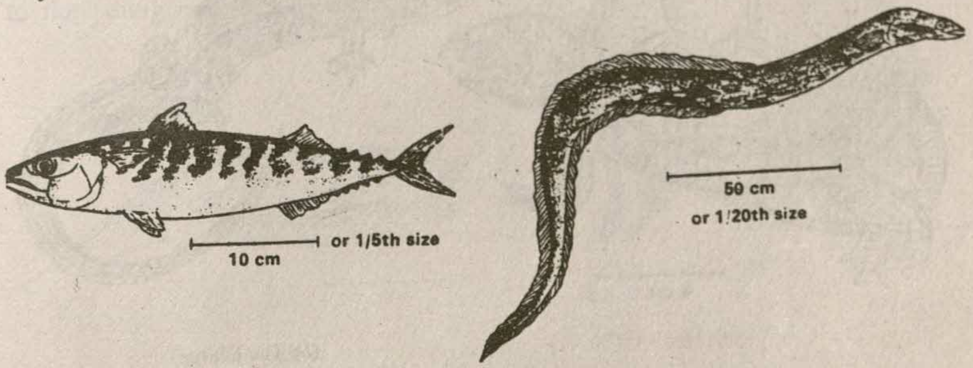
CLASSIFICATION

We have seen that there are millions of different types of objects in the world, and new materials are always being added by scientists. A study of these objects and materials becomes easy if we group these into certain categories such as solid, liquid, and gas, or element, compound, and mixture. The living world is similarly classified into two broad categories—animals and plants. The animals themselves are grouped into two sets; all animals belong to one or the other of these two sets. Animals with backbones are called ***vertebrates.*** Animals without backbones are called ***invertebrates.***

Animals with backbones, the vertebrates, are larger in size and more familiar to us. There is of course a lot of variation among them in the way they move, feed, reproduce, etc. There are five major groups in which the vertebrates are placed as explained below.

VERTEBRATES

Fishes are one of the five major groups of animals with backbones. All of them live and breathe in salt or fresh water; they have special organs for breathing, called gills. They have fins which enable them to move in water, and have scales on their body. Fishes can be found in the oceans upto a depth of almost 7,000 metres.



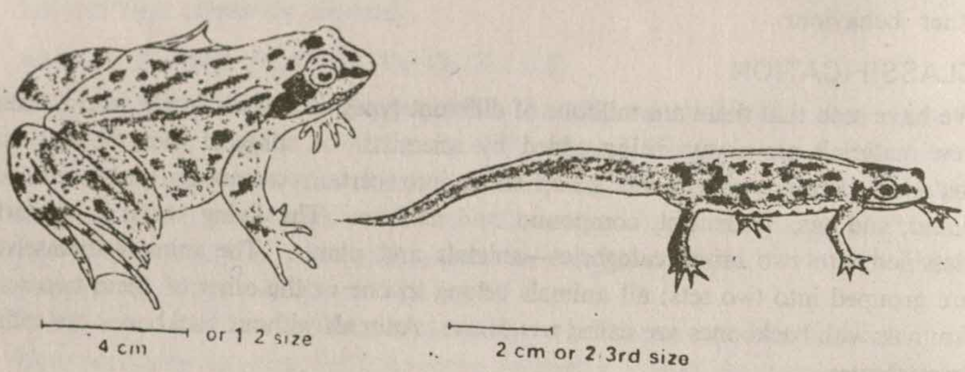
(*a*) A type of fish

(*b*) The eel

Fishes
Diagram 65

They lay eggs which are in most cases covered with jelly-like materials. It is interesting to note that the waters contain plenty of animal as well as plant life; about 90 per cent of all living things are found in the sea.

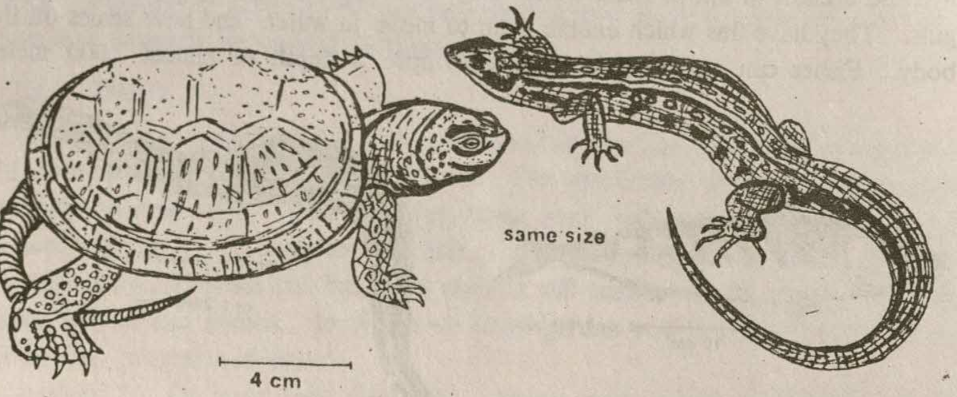
Frogs and newts (diagram 66), belong to the group of ***amphibians***. They live and breathe in fresh water as well as on land. They lay eggs in water and the eggs are covered with jelly. They have legs but no scales on their body.



(*a*) Frog (*b*) Newt

Amphibians
Diagram 66

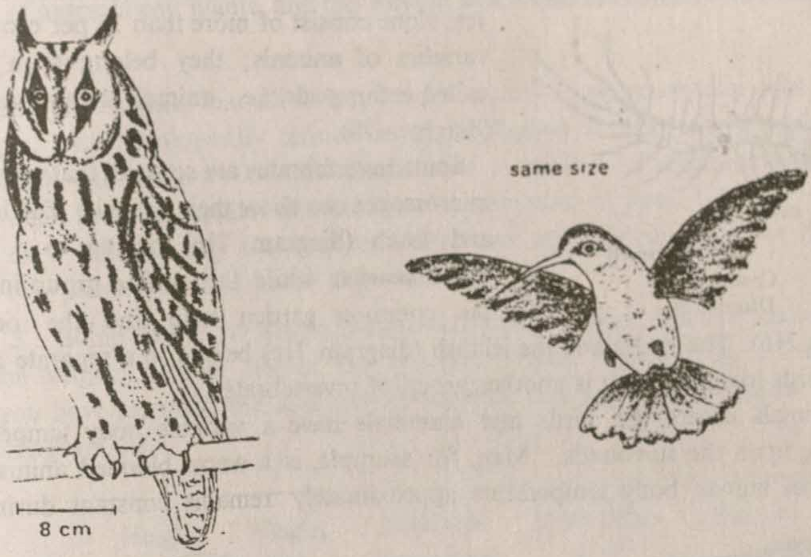
The third major group of vertebrates is the ***reptiles***. They have legs and horny scales. Most of them live and breathe on land, while some, like the tortoise (diagram 67*a*), live in water also. They lay eggs with a leathery shell.



(*a*) The tortoise (*b*) The lizard

Reptiles
Diagram 67

Birds belong to the fourth group of animals with backbones. While they live and breathe on land, they can also fly in the air. They have legs, wings and feathers. They lay eggs with a hard shell.



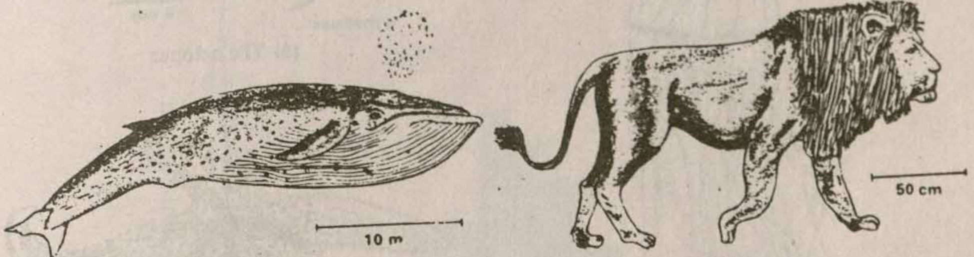
(*a*) Owl

(*b*) Humming bird

Birds

Diagram 68

Man belongs to the fifth group of vertebrates called the ***mammals***. Mammals live and breathe on land. They have legs, and fur or hair, on the skin. They give birth to the young and suckle them.



(*a*) The whale

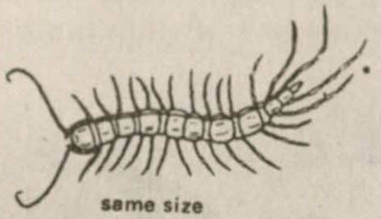
(*b*) The lion

Mammals

Diagram 69

INVERTEBRATES

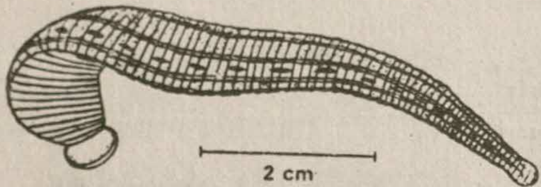
Although vertebrates are more familiar to us, there are many more of those without backbones. Nearly 9.5 lakhs of all types of animals are known to us; of these the vertebrate varieties are only about 54,000. In fact, the insects, which are invertebrates, alone consist of more than 75 per cent of all varieties of animals; they belong to a group called arthropods, *i.e.*, animals with jointed legs (diagram 70).



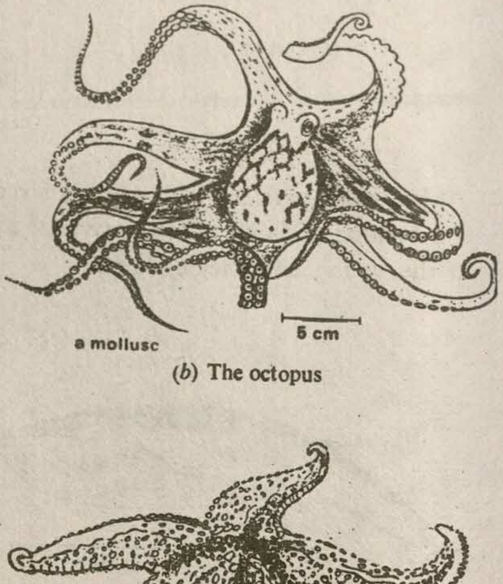
Centipede
Diagram 70

Some invertebrates are so small that only good microscopes can show their presence. Earthworm and leach (diagram 71*a*) belong to a group called ***annelids*** while the ***mollusc*** group includes the common garden snail and the octopus (diagram 71*b*). The hydra and the jellifish (diagram 71*c*) belong to a separate group. The starfish (diagram 71*d*) is another group of invertebrates.

All animals except the birds and mammals have a variable body temperature depending upon the surrounds. Man, for example, is a warm blooded animal and the normal human body temperature approximately remains constant during all

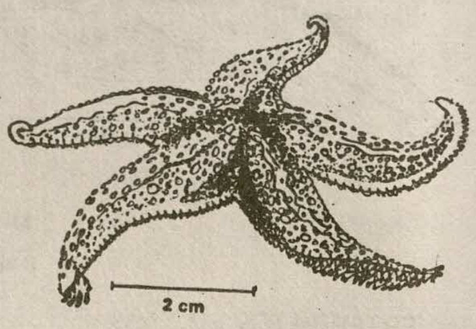


(*a*) The leach



(*b*) The octopus

(*c*) The jellifish



(*d*) The starfish

Diagram 71

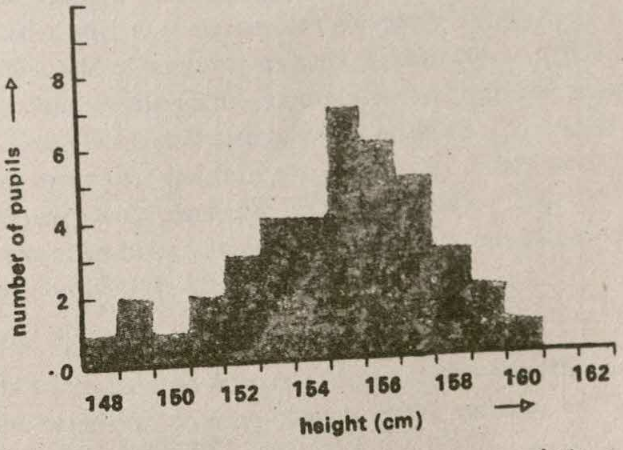
seasons. You can understand much about the method and system of classification by a study of animals and plants, and the ways in which they are similar and different.

VARIATION

It should not be assumed that all living beings in any one variety are identical. For example, man (biologically termed as ***Homo Sapien***) is one of the types of mammals; although basically all individuals have a number of common features (which we shall study in greater detail later on), a number of small but interesting variations exist between any two persons. One such special feature is the finger prints; no two persons have identical finger prints.

Activity 3. Some of the variations between individuals which can be studied in class are the weights, heights, etc. of the students. Select some of these features and after you have recorded the ***data*** for all students, plot histographs like the one shown in diagram 72.

Name	Height (cm)	Weight (kg)	Pulse rate (beats/min)	Body temp. (°C)	Span of palm (cm)
V. Sharma	158	42.5	80	36.5	17
S. Kumar	148	42	80	36.8	16.5
			etc.		



Histograph showing the spread of height among students

Diagram 72

PROBLEMS

1. Pluck about 50 leaves from a tree and find out if any two of them are identical in every respect. Measure their lengths and plot a histograph showing the spread of lengths in leaves from one tree.
2. Collect the thumb print of the left hand of every student in your class. A stamp pad is very convenient to use for applying ink. Observe the print impression through a magnifying glass. Are any two of them identical?
3. Fish differ from the mammals more than they do from any other class of vertebrates. Give three differences between the two classes.
4. One characteristic of all mammals is the presence of hair on their body. What is the use of hair to them? Why do whales have no hair on them?
5. Name two differences between the wings of an insect and a bird.
6. Identify some of the animals and plants shown in diagram 64. Find out in which surroundings they grow, what groups they belong to, and what the animals eat.

12

Plants Around Us

Our environment consists of a rich variety of plants. Most plants are green in colour but some are even red or purple; and some have no definite colour. Some grow wild while others are cultivated. There are poisonous plants and those that have medicinal value.

USEFULNESS OF PLANTS

Most of our food and food products come from plants. All the vegetables, fruits, cereals such as rice and wheat, and pulses such as pea and gram are plant products. Tea, coffee and sugar come from cultivated plants. The paper of this book is made from the pulp of trees. Cotton is grown from which our clothes are made. Coal and wood provide energy; even oil, scientists say, has been formed deep inside the earth from trees which existed millions of years ago on the earth. An important use of plants is that they hold soil from being washed away by wind or rain. These are only some of the obvious uses of plants. There are other important uses which you will appreciate by a close study of plants, their structure and the function of various parts.

Plants may be classified for their study according to many categories. Some plants grow from seeds, give flower and fruits and wither away all in one season of a few months; the mustard plant, paddy, etc. and many small cultivated flowering plants in our garden such as sunflower and poppy are examples of such plants called ***annuals***. The life cycle of some plants such as carrots and radish extends to two seasons in cold countries; they store food in the first year and produce seeds in the second year. These plants are therefore called ***biennials***. A number of other plants continue to grow every year and turn into huge trees. They produce flowers, fruits and seeds every year; such plants are called ***perennials***. The mango, peepul and neem trees are examples of perennials. This classification of plants is made on the basis of the duration of their life cycle,

A FLOWERING PLANT

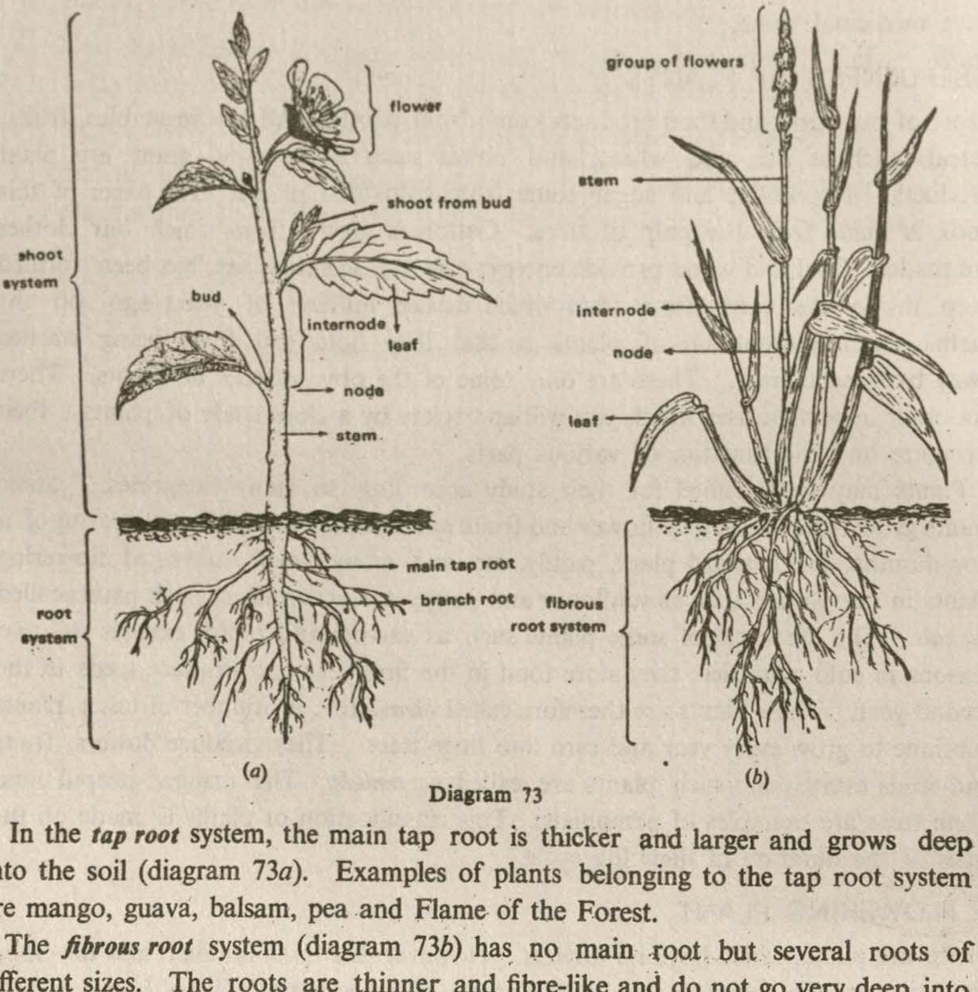
There are plants which have no flowers. However, the most familiar and the most attractive are the common flowering plants. Many varieties will be found in your garden.

Activity 1. Pull out carefully a small plant from the garden so that all of it is taken out without damage. Wash the part of the plant which was in the soil, called the ***root***, and observe how this differs from the part above the ground, called the ***shoot***.

You will notice that the shoot itself has many parts, the most obvious being the leaves, flowers and fruits. However, there are many other similarities to observe in plants and we shall do so systematically.

THE ROOT

The root is that part of the plant which is normally underground; it does not possess leaves, flowers or fruits. Although roots are of several types, there are mainly two types which are most common and easy to identify.



(*a*) (*b*)

Diagram 73

In the ***tap root*** system, the main tap root is thicker and larger and grows deep into the soil (diagram 73*a*). Examples of plants belonging to the tap root system are mango, guava, balsam, pea and Flame of the Forest.

The ***fibrous root*** system (diagram 73*b*) has no main root but several roots of different sizes. The roots are thinner and fibre-like and do not go very deep into the soil Examples of plants which belong to the fibrous root system are onion, palm and bamboo.

Activity 2. Take a wide-mouthed bottle nearly filled with water and place an onion on it with its base resting on the mouth of the bottle. Keep this in a warm place. In a day or two you will observe that roots grow from the base of the onion towards the water in the bottle. Cut off one of the roots and examine the minute hairs on it. A hand lens (magnifying glass) may be used if necessary.

FUNCTION OF ROOTS

Roots perform many functions for survival and growth of plants. By holding firmly to the ground they anchor a plant to the soil; thus, washing away of plant as well as soil is prevented. A tap root system generally fixes a plant more firmly to the ground than a fibrous root system. Soil contains a number of chemicals dissolved in water; a very important function of the root is to absorb water and chemicals from the soil.

Activity 3. Select a small plant from the garden and place it so that its root is inside water in a test tube. Fill some water in another similar test tube. Now plug the opening of the two test tubes with cotton wool. Leave them for about a day or two; notice the level of water in each test tube (diagram 74*a*).

You will observe that the level of water in the test tube containing the plant falls while water level in the other test tube does not. The experiment suggests that roots absorb water. Comparison with the second test tube shows that the loss of water is not due to evaporation. The second tube thus acts as a ***control*** for valid comparison of results.

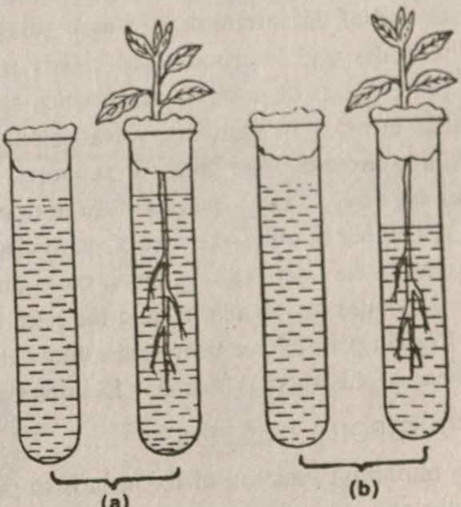
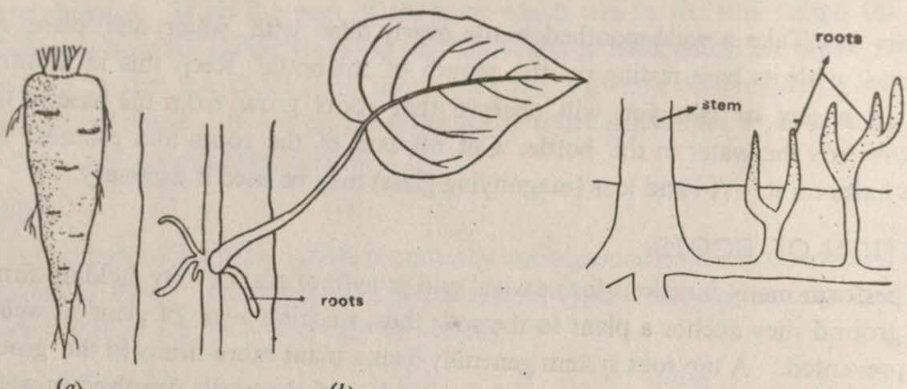


Diagram 74

Roots may also act as storage organs containing surplus food. Carrots (diagram 75*a*) and radish are actually roots which are thick so that they contain a lot of food material. The money plant, pothos (diagram 75*b*), has climbing roots. The roots of mangrove trees, e.g., Rhizophora (diagram 75*c*), come out of the soil. Thus, roots of some plants are modified to perform special functions. Sweet potato and ***dahlia*** have roots which spread out and increase their population without seeds.

THE STEM

The shoot system consists of those parts of the body of a plant which generally grow in the air. The stem is the ***axis*** of the shoot system. It is the main part of the



(*a*) (*b*) (*c*)

Diagram 75

plant body which grows straight up. It bears leaves, buds, flowers and fruits. Most stems are branched but some, such as palms, possess a single unbranched stem.

A stem is divided into a number of short lengths which are called ***internodes***; at each end of the internode is a ***node*** (diagram 73). The leaves grow at these nodes. The nodes and internodes are clearly seen in sugarcane and bamboo.

Some plants have weak stems which cannot grow in erect position. Such plants, called creepers or climbers, spread along the soil in open spaces or climb up by twining around other trees or supports. Examples of such weak stem plants are ***morning glory,*** bean, ***Bougain Villia*** and money plant.

A number of other varieties of stems also occur in nature. Cactus, which generally occurs in very dry regions, has a green and leaf-like stem; in such plants, leaves are very reduced or are absent, and the stem takes on the function of leaves.

Certain plants have their stems under the surface of the soil; they appear swollen when surplus food is stored. Examples are potato, ginger, onion and ***gladiolus.***

TRANSPORT IN STEMS

An important function of the stem is to provide paths for the transfer of foodstuffs, water and various chemicals along its main body. This transport process can be clearly seen by the following experiments.

Activity 4. Cut a round piece of cardboard so as to hold a small balsam plant on a narrow glass bottle. The bottle should contain water, to which a little red ink is added, so that the root is dipped into it. Leave this for about a day. Now cut the plant across the main stem. You will notice the presence of red spots in several definite positions all the way up the stem (diagram 76). These spots mark the presence of channels for the passage of coloured water through the stem. The tubes along which transport of water and chemicals from soil takes place upwards in a plant are called ***xylem vessels.***

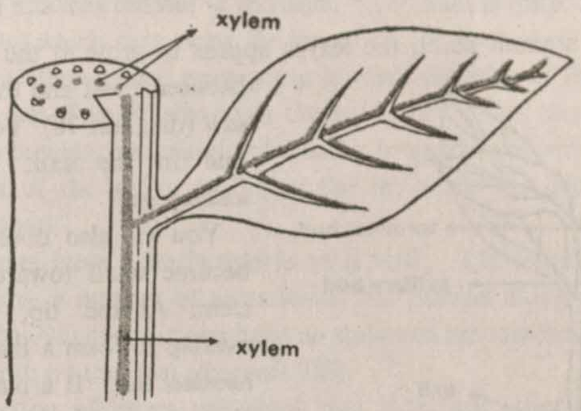


Diagram 76

Transport of foodstuffs also takes place through the stem, and this is carried out downwards in channels called the ***phloem tubes***; these run parallel along the xylem vessels and are very close to the outer bark.

Activity 5. Cut two twigs about 25 cm long from a potted plant. Carefully remove a ring of ***bark*** about 5 cm above one end of one twig without damaging the woody centre; this is best done by making two cuts round the stem about 1 cm apart, and a third cut connecting the two (diagram 77*a*). Now place the two twigs in damp saw dust; the ***ringed*** end should be just outside the saw dust. Water the saw dust daily. At the end of about 2-3 weeks remove and observe the twigs.

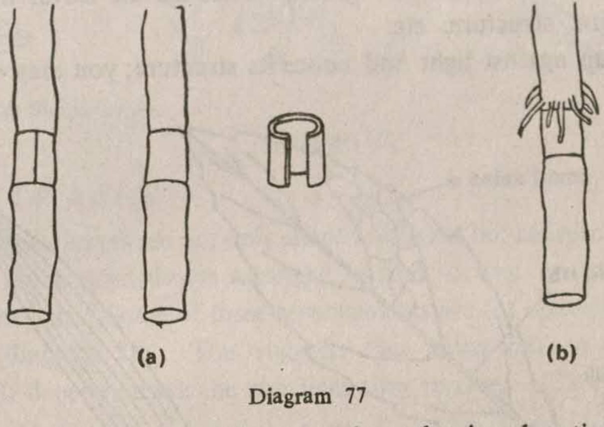


Diagram 77

You will observe that the part of the stem above the ringed section is swollen and shows a growth of roots while the part below the ringed section does not (diagram 77*b*). This indicates that the foodstuffs have travelled downwards along the stem but were prevented to go further down by the removal of the phloem tubes along with the the bark.

BUDS

If you examine a small plant, the leaves appear to grow at the nodes. The angle between a leaf and the stem is called the *axil* (diagram 78). You may see a small bud in the axil. This is called an ***axillary bud***.

You will also observe that the leaves become small towards the tip of the stem. At the tip, very small leaves overlap to form a bud; this is called a ***terminal bud***. If a plant has many branches, terminal buds also occur at the tip of these branches.

The growth of a plant takes place from the buds. The buds are compressed young shoots capable of developing into new shoots. Some of these buds amay also develop into flowers.

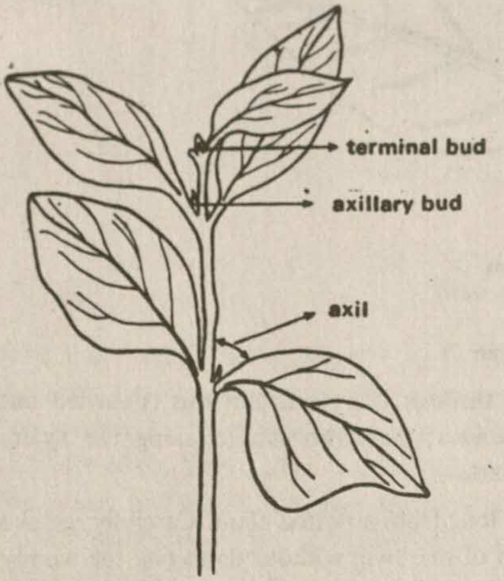


Diagram 78

THE LEAF

Activity 6. Pluck the leaves of some plants. Notice that the leaves grow out from nodal joints where buds have also grown. Arrange the leaves in different group according to size, structure, etc.

Hold a leaf up against light and notice its structure; you may observe a *stalk* (or

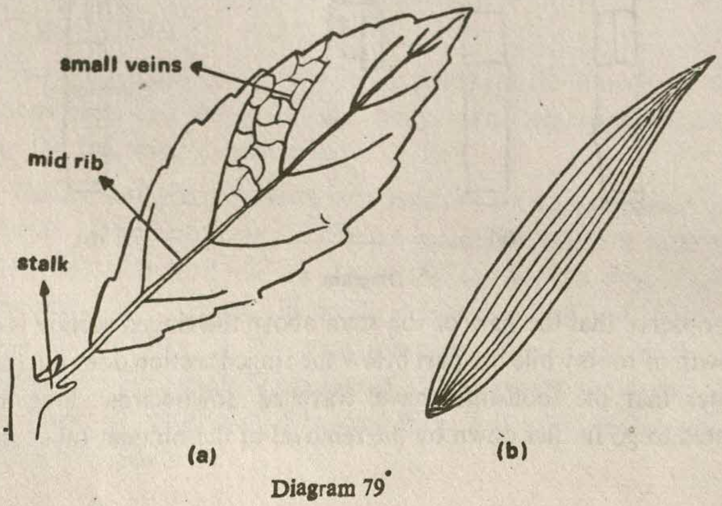
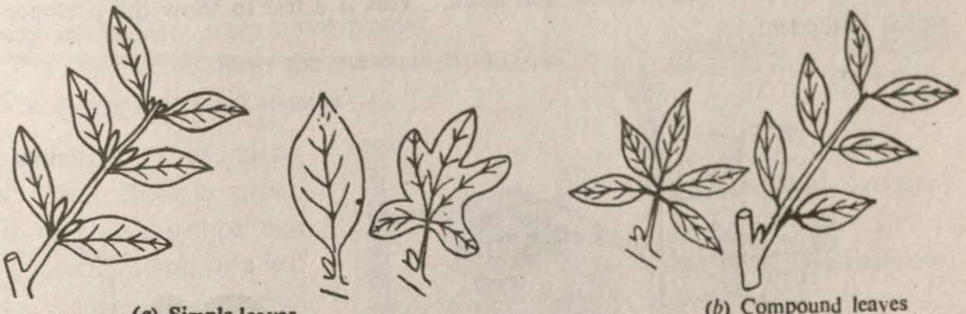


Diagram 79

petiole) which attaches the leaf to the stem. The stalk is thick and contains the main vein (or ***midrip***) which runs along the length of the leaf ***blade*** (diagram 79*a*). The main vein has other branch veins going towards the edge of the leaf blade. A very intricate network of small veins cover the leaf blade. You can feel the veins by your fingers. The boundary or margin of a leaf is irregular; you will also observe that the darker surface of the leaf is up facing the sky while the light coloured surface is facing the ground.

Not all leaves have a single midrib or a stalk. The leaves of grass, sugarcane, paddy, etc. have a number of veins which run parallel along the length of the leaf blade (diagram 79*b*) these leaves have no stalk and are attached to the stem in a way to form a sheath on the stem (diagram 73*b*).

Your collection of leaves will show that there are other ways in which leaves could be grouped. Some leaves have a single leaf blade; these are called ***simple leaves*** (diagram 80*a*). Examples of simple leaves areap ple and mango. On the other hand, the leaf of rose or neem is divided into a number of separate parts called leaflets (diagram 80*b*); such a leaf is called a ***compound leaf***.



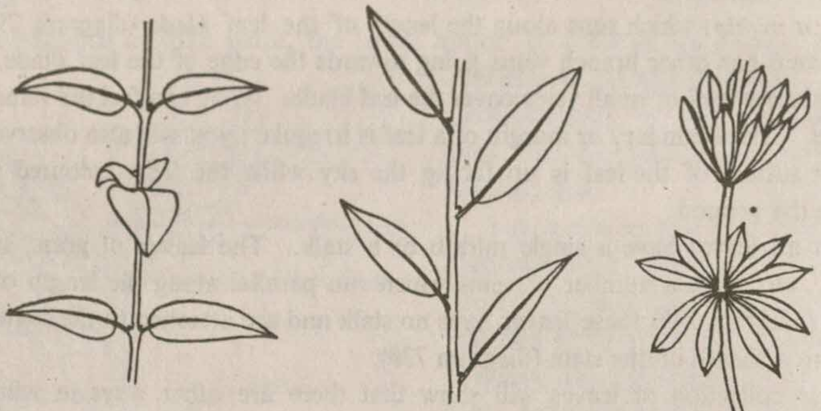
(*a*) Simple leaves (*b*) Compound leaves

Diagram 80

FUNCTION OF A LEAF

In different plants, leaves are not only shaped different but are also arranged in diverse ways. They are almost always arranged in such a way as to receive maximum exposure to the sun. Some of these arrangements are (*a*) opposite, (*b*) alternate and (*c*) whorled (diagram 81). This suggests that leaves have a special function to perform which depends upon the sun light they receive.

Activity 7. Dip one or two leaves in boiling water for a few seconds. Now place them in methylated spirit in a shallow dish and warm indirectly over a water bath. (A beaker half filled with water placed on a heat source is convenient.) The green matter in the leaves is removed and theybecome pale. Now remove the leaves, wash them in water and spread them flat on a glass plate. Cover them with iodine solution



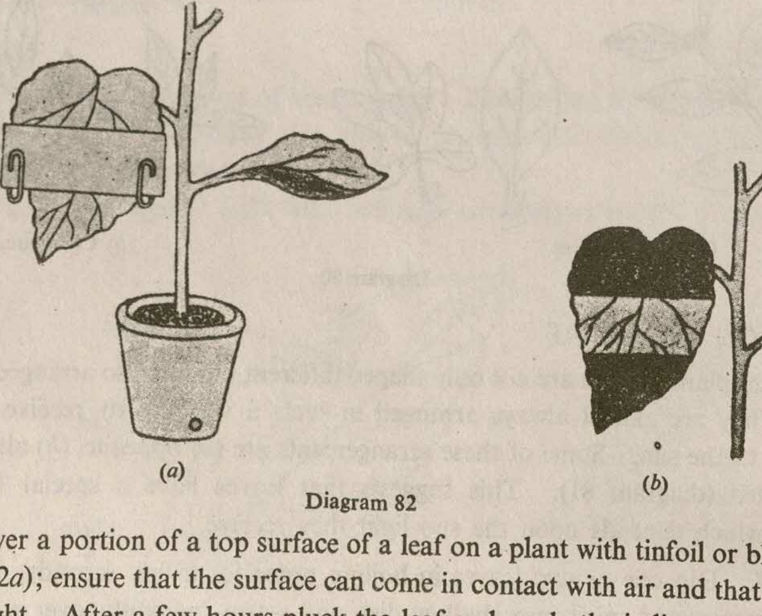
opposite (*a*)

alternate (*b*)

whorled (*c*)

Arrangement of leaves
Diagram 81

and allow to stand for some time. Wash away excess iodine when the parts of a leaf containing ***starch*** will be stained blue black. This is a test to show the presence of starch in the leaf.



(*a*) (*b*)

Diagram 82

Now cover a portion of a top surface of a leaf on a plant with tinfoil or black paper (diagram 82*a*); ensure that the surface can come in contact with air and that the plant is in sun light. After a few hours pluck the leaf and apply the iodine test for starch.

The covered portion of the leaf does not turn blue-black whereas the other portion exposed to sunlight shows blue colouration (diagram 82*b*). The experiment shows sun light is essential for formation of starch in leaves.

PHOTOSYNTHESIS

The manufacture of starch is the main function of leaves in a plant. This process carried out during day time is called ***photosynthesis***. In the process, carbon dioxide is taken in by the plant from the air and oxygen is given out. Starch is the food of plant, and it is then transported to other parts of the plant for storing and utilisation. Leaves are the food organs of a plant. The manufacture of food is made possible by a green coloured matter present in the leaves called ***chlorophyll***. (It is possible to show by chromatography that chlorophyll is made up of several pigments.) In some plants the function of leaves to carry on photosynthesis is carried out by other parts of the plant such as the stem of a cactus.

TRANSPIRATION

Leaves also remove excess water from a plant in the form of water vapour. This process is called ***transpiration***.

Activity 8. Take a large Hibiscus leaf and plunge it in warm water at about 70°C. You will observe that bubbles form on the surface of the leaf. There are many more bubbles on the underface than on the upper surface. Repeat the experiment using leaves from some other plants.

The experiment shows the presence of small pores on the surface of the leaves. These pores are called ***stomata***.

Activity 9. Fix two pieces of cobalt chloride paper, one each on the upper and the lower surface, of a leaf of a plant using two glass slides and rubber bands (diagram 83). Within a few minutes the colour of the papers will turn pink showing the presence of water. Repeat the experiment with leaves on other plants.

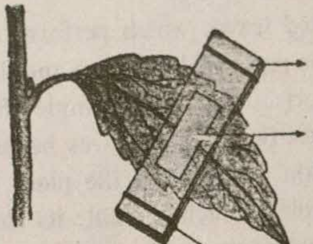


Diagram 83

Activity 10. Seal two pots, one with a plant in it and the other without, using polythene bags. Place them on two glass plates, cover them with bell jars and seal the edges with a jelly (diagram 84). Examine them after about an hour. You will notice drops of a liquid collected inside the jar which contains the plant while the control set up (without the plant) does not show any liquid formed. The cobalt chloride test will show that the liquid is water.

Plants give off to the atmosphere a large amount of water which they absorb from

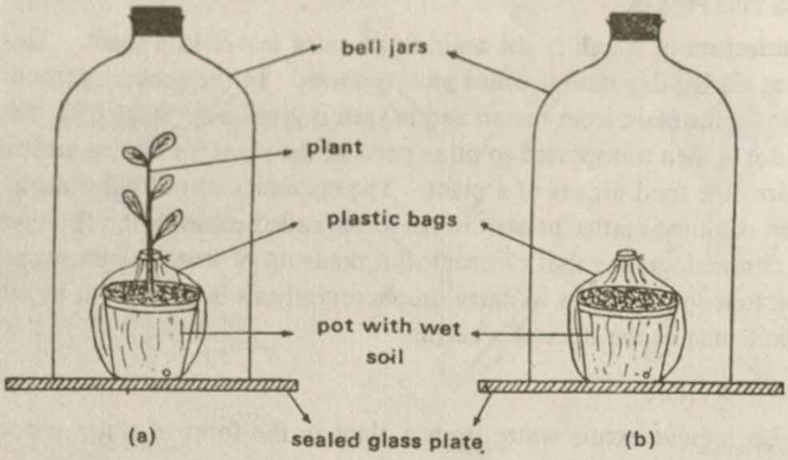


Diagram 84

the soil through the roots. A large tree may give away as much as one tonne (1,000 kg) of water in one day by transpiration.

Like all other living things, plants carry out ***respiration*** throughout day and night. During this process, oxygen is taken in and carbon dioxide is given out through the stomata.

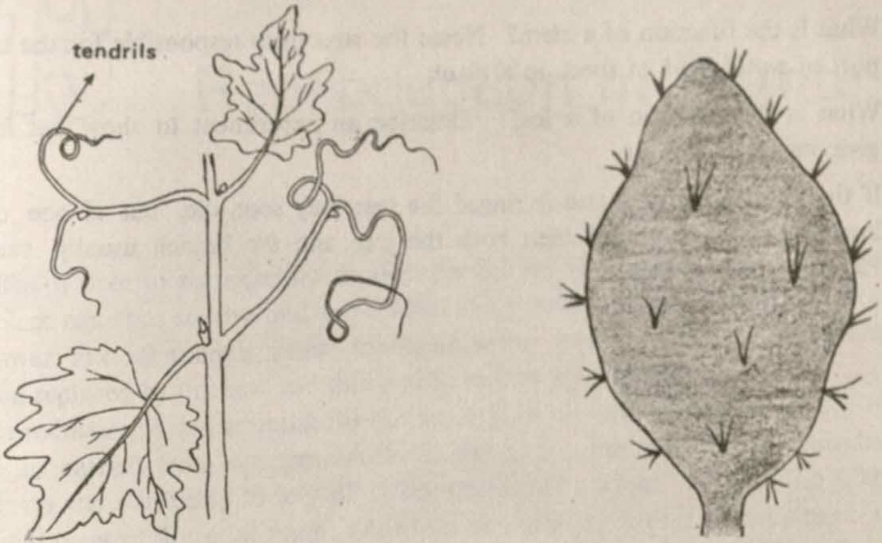
MODIFIED LEAVES

Many plants have modified leaves which perform additional functions. In plants with weak stems, leaves or parts of leaves are modified into ***tendrils*** which help the plant in climbing on supports. Pea is an example of such a plant (diagram 85*a*).

In dry regions, the leaves or parts of leaves become modified into spines. They help to reduce transpiration and protect the plant from grazing animals. Cactus (diagram 85*b*) is an example of such a plant; its stem is then green and serves the function of a leaf to manufacture food.

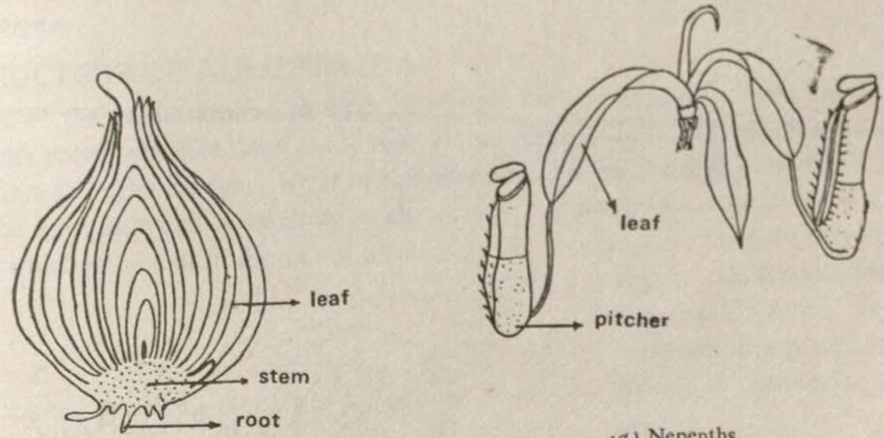
Some plants such as onion (diagram 85*c*) have thick and fleshy leaves which store food or water. The pitcher plant Nepenthas (diagram 85*d*) is an insectivorous plant in which leaves are modied for capturing and digesting insects; these plants grow in soil which are deficient in nitrogen compounds.

We have noticed that a plant is a living organism which takes water from the soil, carbon dioxide from the atmosphere and energy from the sun for its survival and growth. In this process the roots, stem and leaves play a vital and mutually supporting part. These structures which are described above are called the ***vegetative*** parts of a plant. In some plants these parts perform modified or additional functions. In flower, seed and fruit are not described earlier because they have a very different yet vital function to perform; we shall study about these next.



(*a*) Pea plant

(*b*) Cactus



(*c*) Onion

Diagram 85

(*d*) Nepenths

PROBLEMS

1. What are annual and perennial plants? Give two examples of each.
2. Draw a simple diagram of a flowering plant and name some of its important structures.
3. What is the function of a root? Name two types of root systems and compare them. Name one plant of each type. Which of the two types would most large trees have? Why?

4. What is the function of a stem? Name the structures responsible for the transport of water, and of food, in a plant.
5. What is the function of a leaf? Describe an experiment to show that leaves give out water vapour.
6. If the lower stem of a tree is ringed the tree may soon die, but if one of its branches is alone ringed then both the tree and the branch usually survive. Explain why this happens.

13

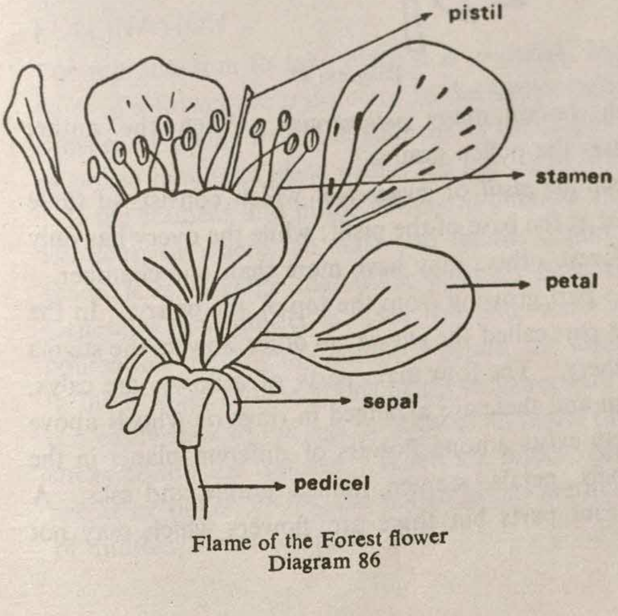
Reproduction in Plants

A plant is able to manufacture its own food from the various sources around it; the plant can thus survive and grow when the vegetative organs function properly. However, like all animals, plants too must wither away and die. One generation is then replaced by the next and this is achieved by ***reproduction***.

Reproduction is not essential for the survival of a plant but it is necessary if life is to be carried from one generation to the next. The process of reproduction preserves the particular variety of living organisms. There are over 2.5 lakhs of different types of flowering plants known to us and in most of them the flower is the main organ which is responsible for reproduction. It is therefore called a ***reproductive organ.***

STRUCTURE OF A FLOWER

Most of the plants around us bear flowers as they grow older. The flower may be very prominent, like those of the rose, Flame of the Forest, Balsam, etc. or inconspicuous as in the mango. Most of the plants produce flowers at a particular time of the year, although some do so in all seasons. A flower develops from the flower bud which is present in the axil of a leaf or at the tip of a shoot. Flowers may appear singly or in groups (diagram 73*a* and *b*). When they are arranged in a group, such a cluster is known as ***inflorescence***.



Flame of the Forest flower
Diagram 86

Activity 1. Observe how the Flame of the Forest flower is joined to the stem or branch by a stalk; the stalk is called the ***pedicel.*** Cut carefully the flower along with the pedicel. Now examine the various parts of a flower step by step.

On the outside at the base of a flower are green leaf-like ***sepals.*** These sepals form a whorl called the ***calyx.*** When a flower is in the bud stage, the calyx completely covers it and thus protects the inner parts of the bud. When the sepals are green, they also serve the purpose of manufacturing food for the plant. In the flame of the forest, there are five green sepals which are not joined together.

Inside the calyx of this flower is another whorl, called the ***corolla***, which contains five orange-yellow coloured ***petals*** not joined together. Some plants such as sweet pea and rose have sweet scented petals. Most of the attraction of flowers is in the colour which the petals have. Their bright and diverse colours and the scent serve to attract insects to the flower. The corolla also serves to protect the inside of aflower during its bud stage.

Within the petals one more whorl of thin thread-like structures exists. The whorl is called the ***androecium*** and each structure is called the ***stamen.*** The stamen itself has two main parts, a filament and a small box at its tip called the ***anther*** (diagram 87). The flame of the forest has ten stamens and each anther is made up of four tiny sacs which contain many ***pollengrains.*** When the anther is mature, it splits open and releases the pollen grains.

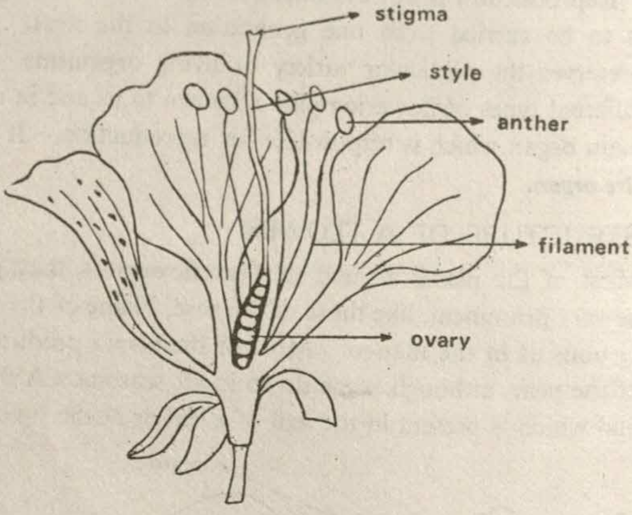


Diagram 87

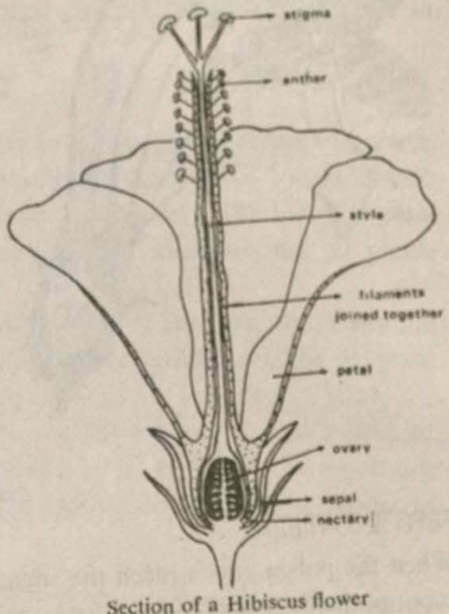
In the centre of the flower is seen the ***pistil*** or ***gynaecium*** which consists of three parts. The ***ovary*** is the swollen part at the base of the pistil; while the overy has only one chamber in the flame of the forest, others may have more than one chamber.

The ***style*** is the thin filament-like part growing from the top of the ovary. In the flower, the style ends in a flattened part called the ***stigma***; in other flowers the stigma may be knobbed, branched or feathery. The four main parts of a flower are calyx, corolla, androecium and gynaecium and these are arranged in rings or whorls above the stalk. However, a great variety exists among flowers of different plants in the number, colour and shape of sepals, petals, stamen, pollen grains and sacs. A complete flower contains all the four parts but there are flowers which may not contain all the parts.

NECTARY

Many flowers have a ***nectary*** which secretes a sweet liquid called the nectar. Bees, moths, butterflies and other kinds of insects like the sweetness of the nectar. In sucking up the nectar, and visiting the flowers in search of the pollen grains, these animals help the process of reproduction in plants.

The stamens are called the male structures of a flower; the pistil is the female structure of a flower. The flame of the forest has both the male and female structures; it is therefore called a ***bi-sexual*** flower. A ***unisexual*** flower possesses either the stamens or the pistil; it is therefore either male or female.



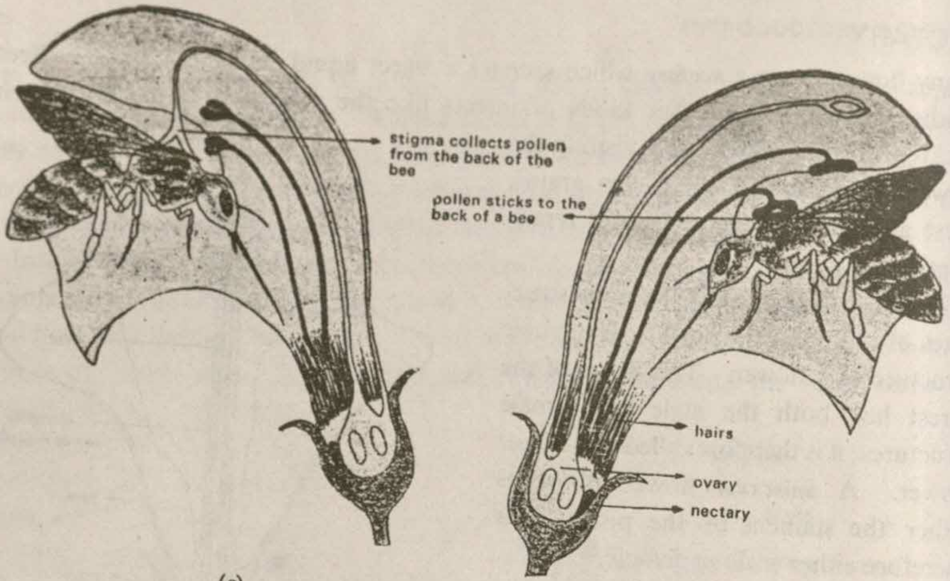
Section of a Hibiscus flower
Diagram 88

Activity 2. Take a Hibiscus flower and study its various parts. Observe these structures and compare with those of the flame of the forest flower. Cut a vertical section of the Hibiscus flower through the ovary and compare its appearance with the structures shown in diagram 88. The ovary contains small round structures that are the eggs of the flower; they are called the ***ovules***.

POLLINATION

For reproduction to take place it is essential that the pollen grains from the male parts of a flower are transferred to the female part of the same type of flower. This transfer of pollen from the stamens to the stigma is called ***pollination***. The transfe- of pollen may take place within the same flower or to another flower.

If the stamens and pistils mature at different times as in the case of sunflower and Hibiscus, or where the male and female organs of reproduction are separated in space, it is essential that other agencies must help the transfer of pollen grains. Generally this transfer is aided by wind, water and insects. In the case of insect pollination the brightly coloured petals, the scent and the nectar attract he insects to the flowers. Pollen grains of these flowers are large and rough on the outside and can easily stick to the legs or body of an insect (diagram 89*a*); the stigma may also be sticky to aid the transfer. When the insect visits another flower in search of more nectar or pollen grains, the pollen grains are unintentionally deposited on the stigma of another flower (diagram 89*b*).


stigma collects pollen from the back of the bee
pollen sticks to the back of a bee
hairs
ovary
nectary

(*a*) (*b*)

Diagram 89

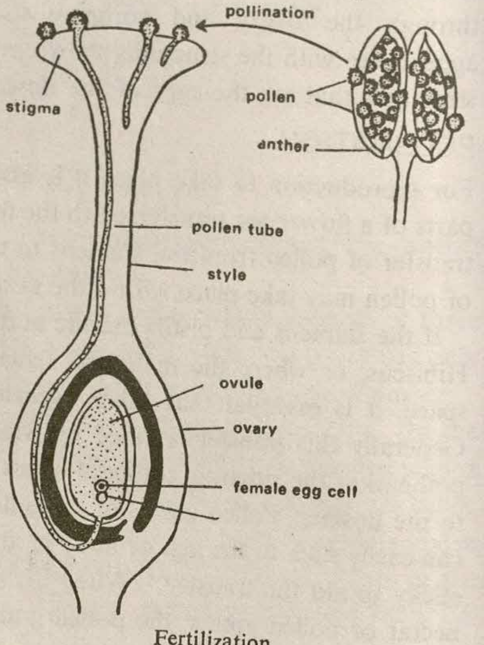
FERTILIZATION

When the pollen grains reach the stigma they give out a pollen tube. The pollen tube gradually extends in the style and enters the ovary. The active part in the tube is the ***male cell*** which fuses with a ***female egg cell*** (diagram 90). This process is called ***fertilization.*** Several ovules may get fertilized by several pollen grains and form seeds.

When fertilization takes place the ovary wall grows and the ovary becomes a fruit. Examples of some fruits are grapes, coconut, watermelon and tomato. The fleshy part of the fruit protects the seeds inside from any injury; in addition, dispersal of the fruits by water, birds and human beings enables the seeds to go long distances.

GERMINATION

When the seeds fall on the ground and obtain favourable environment of air, water and temperature, they form a



Fertilization

Diagram 90

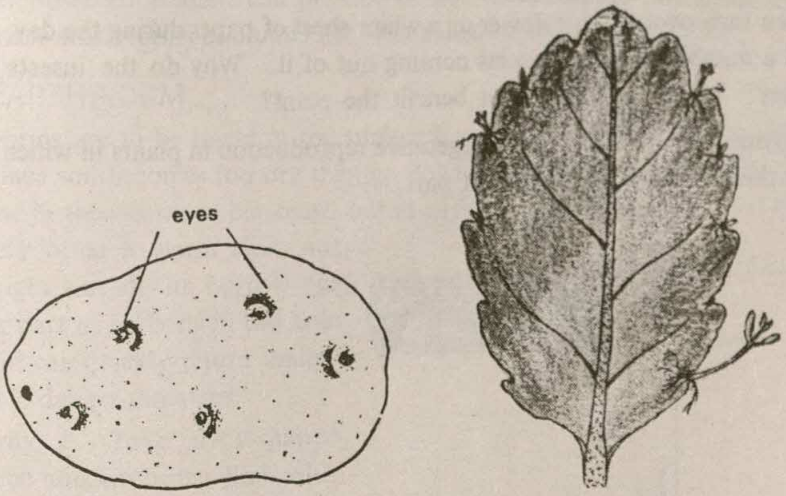
plant similar to its parent plants complete with stems, roots, leaves and flowers. This process of the seeds developing into living plants is called *germination.* Thus new lives make a beginning and the particular plant variety continues its existence on the earth.

VEGETATIVE REPRODUCTION

The life of a new plant starts from a seed and it goes through the stages of growth, reproduction and death. The process of reproduction is carried out by the flowers which produce seeds when pollination and fertilization occurs. The life of a plant starts from a seed and in most cases ends up in a seed. However, not all plants transfer life to the new generation in this way.

Vegetative reproduction is a process in which the transfer of life from one generation to the next takes place without seeds. In this process a vegetative organ on the plant gets broken from the mother plant and starts to grow as an independent plant.

Activity 3. Potato is a modified stem which grows underground. Cut a piece of a potato such that it has one or two *eyes* (diagram 91*a*) on it. Place this piece in a moist soil and observe after about a week. You will notice that the eyes sprout to form new plants.



(*a*) A potato tuber

(*b*) A Bryophyllum leaf

Diagram 91

Begonia or a Bryophyllum leaf (diagram 91*b*) when detached from the parent plant gives rise to many new plants. You may have noticed that a stem cut from rose can develop roots and other organs. An entirely new plant grows from such a cutting and this method is widely used. Thus, although nature has its own varieties of vegetative reproduction, artificial methods are now widely used.

PROBLEMS

1. What is the importance of the following parts ot a flower to that kind of plants: (a) petals; (b) sepals; (c) ovary.
2. (*a*) The coconut can float in water and travel great distances in water away from the parent plant. (*b*) The seed of Maringa has wings so that it can float in the air.
   Explain the importance of these two functions to the plants.
3. Collect flowers from about half a dozen different plants. Observe their petals, pollen grains and the arrangement of the calyx, corolla, androecium and gynaecium.
   (*a*) Which of the flowers have bright coloured corolla, and which of them have small and inconspicuous petals?
   (*b*) Which of the flowers have a large number of pollen grains?
   Explain in at least two cases the advantages to the plants of the structure, colour and size of petals, and the amount of pollen grains.
4. Draw a clear and labelled diagram of a familar flower showing the various parts.
5. If you turn over a large flower on a white sheet of paper during the day, you may find a number of small insects coming out of it. Why do the insects visit the flower? How does their visit benefit the plant?
6. Give one example each of the vegetative reproduction in plants in which the stem and the leaf plays an important part.

14 Animals Around Us

To many of us the word animal suggests the wild animals of the forest such as lions, tigers and bears, or the more familiar domesticated ones such as cows, horses, sheep, dogs and cats. Besides these four footed vertebrates, there are numerous other forms of animal life. They range from the very tiny creatures which can be seen only through powerful microscopes to the large whale. In fact, the invertebrates form nearly 95 per cent of all forms of animal life.

The use of domesticated animals to man is obvious; they are employed for tilling the land, carrying heavy loads, in the transport of men and materials, and providing us food and milk. A number of other small animals, however, play a very important part in our lives; for example, insects are agents of pollination in flowers and thus help in the formation of seeds, fruits and next generation plants. A closer observation alone can provide us this information. We shall now study some other small forms of animal life which are of importance to us.

THE EARTHWORM

Earthworms are to be found in the surface layers of moist soil in our gardens. If the surface soil becomes too dry they go down to moister region. They spend the day time in their *burrows* but crawl out at night in search of food. You will notice that very often a worm does not come right out of its burrow but keeps a part of its body in the hole so that it can quickly return underground if danger threatens.

Activity 1 Take a T-shaped glass tube and wrap one limb with a black paper or cloth. Now take two or three earthworms and allow them to enter the glass tube from the lower end (diagram 92). Plug the ends with cotton wool, place the tube in sun light and watch the movement of the worms.

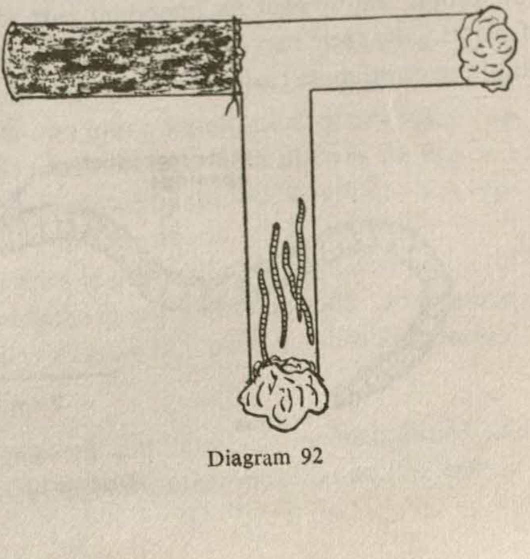


Diagram 92

You will observe that the earthworms settle down in the covered limb of the T-tube under darkness. An earthworm has no eyes but can tell when it is near the surface because its front (*anterior*) end is sensitive to bright light. A worm has no ears either but can be aware of vibrations staying in its burrow when a bird is hopping on the ground overhead. Earthworm is the food of birds. What does a worm feed on?

FEEDING

When an earthworm moves in the soil, it tunnels its way by force as well as by eating its way through the soil. It obtains nourishment from decayed animal and plant remains such as dead leaves that are present in the soil it swallows. The soil is ground up inside its body. You may notice casts at the entrance of the burrows; these are formed by the finely divided soil that passes out of the body of earthworms. The fine soil is struck together by a fluid secreted by the worm's skin.

Activity 2. Make a ***wormery*** to observe the feeding and other habits of earthworms. Take a large glass jar and line it with pebbles at the bottom. Place layers of damp soil and sand alternately on the pebbles so that the arrangement resembles a layered cake. Press the surface down to make it smooth and put in 3 or 4 large worms. On the surface scatter a few pieces of fresh and fallen leaves. Cover the jar with a cap of black paper and make holes in it for air to enter. Stand the jar in a quiet and shaded place.

You will observe the worms making their burrows; the layers of sand and soil become mixed together and the leaves on the surface decrease in number. The leaves are drawn in the burrows to be eaten by the worms; usually their stalk is grasped and pulled.

IMPORTANCE OF EARTHWORMS

Few people realise what an important part earthworms play in relation to growth of plants. By their burrowing activities they loosen the soil so that roots of plants can grow down more easily. The entrance of rain and air into the soil is helped by

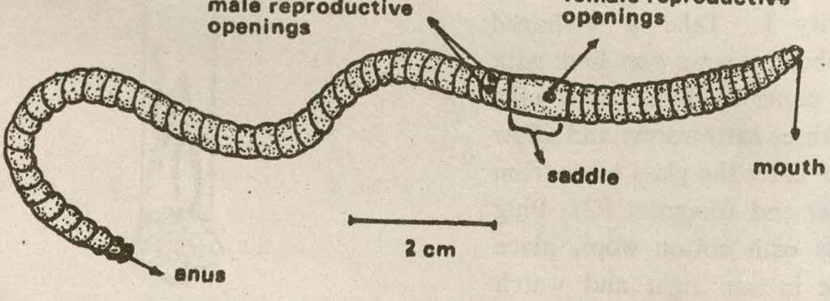


Diagram 93

the burrows which drain and aerate the soil. Leaves which have been dragged into the burrows but not eaten enrich the content of the soil with vegetable matter and chemicals when they decay. Worms can move to the surface soil from as great depth as 50 to 60 cm, and cover it by a layer of finely powdered material. This results in the gradual covering up of the stones on the surface.

STRUCTURE AND MOVEMENT

An earthworm has a long, narrow body rounded throughout its length; when fully grown it can measure over 20 cm in length. An earthworm is reddish brown in colour; its upper (or dorsal) surface is always darker than the lower (or ventral) surface. The mouth is at the narrow front end; it has an opening called the anus at the flattened back end through which it throws out the waste matter present in its body.

The whole body is divided into a number of rings or segments which may vary from 100 to 120. In mature earthworms, about a quarter of the way from the front end some of the segments (about 4 to 6) are thicker and form a band known as the saddle. When the worm is crawling, the segments contract and lengthen.

Activity 3. Place a worm on a rough paper and allow it to move; you will hear a scraping noise. Move your finger over its body on the ventral and dorsal surface. The lower surface feels rough because of a number of stiff hairs or ***bristles*** on it. Place the earthworm on a piece of smooth glass and watch how it moves.

When a worm crawls over a surface the bristles are pushed into the ground to obtain a firm hold. Thus, by using its bristles the worm moves by alternate lengthening and shortening of its body. The earthworm finds difficult to crawl on a smooth surface because it cannot find a good foothold.

REPRODUCTION

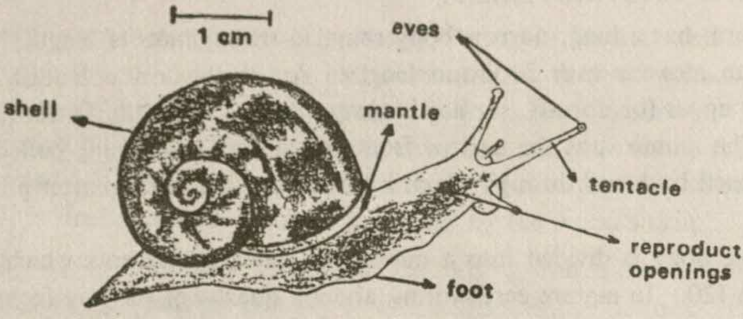
An earthworm has both male and female reproductive organs; it is therefore called a ***hermaphrodite***. However, it is not possible for the male reproductive cells of earthworm to fertilize its own eggs in its own ovary. Fertilization occurs when two worms come together and exchange their male cells, and takes place in the egg case ***cocoon***. The cocoon is made from mucus produced by the saddle region. The eggs hatch out (usually one from each cocoon) into baby worms.

A very interesting thing about earthworms is their ability to grow lost parts. If a worm is cut into two, the part containing the mouth and brain soon grows a new tail; the other part often dies. This ability to grow lost parts is called ***regeneration***.

THE SNAIL

The snail belongs to a group of unsegmented and soft body animals called the Molluscs. While the snail lives on land, most of the other members such as oysters and the octopus live in water; the sea shells found near the shore were once the home of some of these small animals.

In the day time, snails can be found hiding behind bricks, flower pots or stones. They come crawling out at night in search of food; they may even come out during the day if the weather is damp and cloudy.



The garden snail

Diagram 94

STRUCTURE

The coiled shell is the most prominent part of a snail's body. It withdraws into the shell in times of danger. The main part of the body outside the shell is called the foot. This is made of tough muscles and the snail moves with the help of these. The head bears four ***tentacles***; the longer ones are called horns and these bear the eyes at their tips. The two small ones below the large tentacles are also sensitive to touch and may be used for smelling. At the front end of the snail just beneath the head is the mouth. A snail has no internal skeleton and is almost all muscles.

Activity 4. Place a snail on a glass pane and watch its movement through the glass. Touch a feeler (tentacle) with a pencil; see how it is withdrawn. Disturb the snail further; you will observe that it withdraws its body into the shell.

When a snail glides over smooth or rough surface, the muscles of the sole of the foot form very small waves of contraction and elongation; it leaves behind a colourless sticky discharge which forms a trail. This mucus is secreted by a gland which is just behind the mouth. The mucus is so effective that a snail can be made to glide on a sharp edge of a razor blade without any cut.

BREATHING AND HIBERNATION

The snail breathes in and out through the breathing hole which is in the ***mantle***. The hole leads to the lung chamber and if you watch it carefully, you will see it open and close as the snail takes in air and gives it out during breathing.

As winter approaches, snails prepare to ***hibernate***. Having found a suitable place in which to hide and where they will be undisturbed, they close the door with slime which hardens and keeps out the cold. Care is taken to make a little hole in the middle of the door through which air can pass for breathing. The animal then curls into its shell and sleeps continuously during the winter months. During hibernation the breathing rate is also lowered.

FEEDING

Snails feed on young plant shoots, leaves and vegetables. A very small horny jaw tears the leaf; then the tongue covered with about 25,000 tiny teeth rubs the leaf and grates it into tiny pieces. The food then passes into the snail's stomach which is placed above the middle of its foot. The very large number of tiny teeth are so effective that a snail kept inside a cardboard box can easily come out boring a hole through it.

Snails themselves are the food of birds, toads, etc. For this reason they rarely come out for feeding during the day. They eat many kinds of plants and destroy most of the vegetables; for this reason they are most unwelcome visitors to the garden.

REPRODUCTIQN

Like the earthworm, the snail is also hermaphrodite possessing both male and female sex organs. The male sex organs ripen first. To begin with, therefore, a snail is male and at about the age of 3 it becomes a female and lays eggs after fertilization occurs when it comes together with another male snail. The eggs measure about 3 mm across and are protected by small brownish coverings. Usually the snail lays about thirty eggs at a time in a moist spot behind a large stone or some other well concealed place. The eggs hatch into baby snails in 3 to 4 weeks. The baby snails know by instinct what to eat and where to find it; they are therefore not dependent on their parents once the eggs are laid.

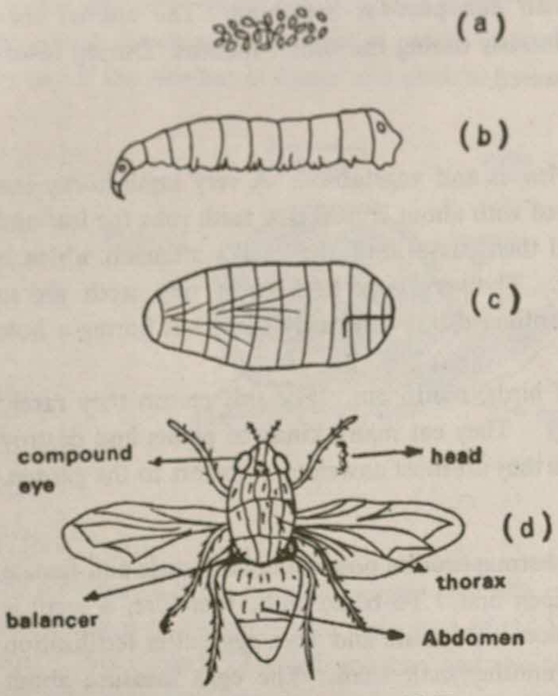
HOUSE FLY

The housefly is a familiar example of a group of animals called the insects. There are about a million different types of insects known to us, and scientists say that the first insect appeared on the earth about 300 million years ago. This shows that they are well adapted to their environment. There are certain common features which all insects have; these are : (a) Three pairs of legs, (b) Three body regions, (c) One pair of antennae, (d) One pair of *compound* eye, (e) Uually two pairs of wings.

STRUCTURE

The body is divided into head, ***thorax*** and ***abdomen*** (diagram 95). On top of the head of a housefly are three simple eyes and on each side is a large compound eye. The compound eye is so called because each contains about 4,000 simple eyes put together. The antennae which are also on the head are short with three joints.

The thorax bears the jointed hairy legs which end in two claws. Between the claws are two small pads which secrete a sticky substance which helps the fly to cling to the surface on which it is walking. This enables the fly, as you may have noticed, to walk upside down on the ceiling. The fly has only one pair of wings which are fixed to the thorax. The wings are transparent with a network of veins. Instead of a second pair of wings which some other insects possess, the fly has a pair of short projections behind the wings which are called ***balancers***, because they are used to balance the fly in its movement. The abdomen is the hind part of a fly and it contains the organs for digestion. The fly has no lungs and does not breathe in the same way as we do. Instead of lungs, it has a network of little tubes called ***tracheae***. These are arranged all over the body and air passes into them through ten small holes along each side of the body.



(*a*) The adult fly (*b*) Eggs (*c*) Larva (*d*) Pupa
Diagram 95

DEVELOPMENT

Houseflies are found all over the world and breed on almost any decomposing matter as long as it is warm and moist. A female lays five to six batches of 100 to 150 eggs. Each egg is about 1 mm long.

From the egg stage to its adult form the fly goes through various stages of development. Within a day of the laying of an egg, it hatches into a ***larva*** which is about 1.25 cm long and has twelve segments (diagram 95*b*). It is widest at the back and tapers towards the front where the head bears a hook with which the larva tears up food and drags itself along. There are two tiny breathing holes, one each on the second and the last segment.

By the fifth day the larva shortens and the skin becomes a barrel-like case called the ***pupa*** (diagram 95*c*). During the next four days the pupa changes from white to dark brown, a lot of tissue breaks down and the inside goes through a lot of changes. By the tenth day the fully grown fly escapes by pushing off the front end of the pupal case, and by the 23rd day the new generation starts to lay eggs. The adult fly looks completely different from its earlier stages and is said to undergo ***metamorphosis*** in its development.

FEEDING AND SPREAD OF DISEASES

The fly cannot bite its food; when it settles on any solid matter such as sugar it pours ***saliva*** down a small tube called the ***proboscis.*** The saliva dissolves the sugar and then the sweet liquid is drawn up through the tube.

Flies feed on excreta and vomit as well as on our foodstuffs. In this process they help transfer diseases such as typhoid, cholera, diarrhoea and dysentery. This may happen in any of the following two ways.

(*a*) As the fly's body and legs are covered with hairs, the harmful ***bacteria,*** which are responsible for the diseases, are easily transferred to the foodstuffs on which it walks and settles for feeding.

(*b*) Whilst feeding on infected matter, harmful bacteria may be taken in through the proboscis, and deposited on foodstuffs through the saliva.

Prevention of the spread of disease by flies may therefore be carried out by keeping all food covered, waste food being burnt or buried daily, and latrines kept clean. Compost heaps should be covered with a layer of grass or earth.

Activity 5. Go on an inspection of the kitchen and compound. Make a note of all situations where it would seem possible for flies to spread diseases. Suggest methods of making those situations safe from flies.

Spiders and some birds eat flies and help to reduce their numbers; however, the greatest prevention against diseases borne by flies is cleanliness.

HONEY BEE

Many insects are harmful in one way or the other; but there are others such as the silk worm, lac insects and the honey bee which are useful to us. An important use of the bees is that they help in pollination and thus further the growth of future generation of plants. Bees are reared for honey and wax. The honey bee is a social insect; this means that it lives in a community in which different types of jobs are shared by different types of the insect. Three different kinds of bees live together in a bee colony.

THE QUEEN BEE

The queen bee is the fertile female whose function is reproduction. She can lay fertile eggs continuously upto four years. The queen bee has a very large abdomen which extends beyond the wings. The queen bee produces a substance from glands exuding on to her body surface; the attendant workers lick the substance and pass it from bee to bee and the colony continues to live together harmoniously.

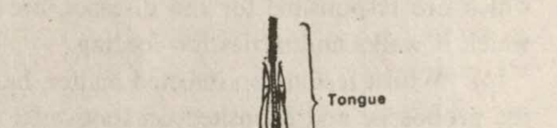
The *bee hive comb* is made up of cells in three sizes. The smallest and middle size cells are six sided (hexagonal) while the largest size cells are thimble shaped and oval. The queen lays eggs in them and their development into the larvae and pupa stages takes place in them. The two smaller size cells are also used for storing of honey or pollen from flowers.

The *drone* is the male bee and is reared in the middle size cell. His only function is to mate with a virgin queen during the marriage flight. If there are any drones still living in the colony in autumn, they are driven out of the hive to perish.

THE WORKER BEE

The worker is smaller than the drone and does not lay eggs; its task varies with age. The workers are reared in the smallest cells of the bee hive. For the first three days after hatching they take food from other older workers. From 3 to 12 days they act as nurse bees feeding the larvae in the cells of the comb. From 12 to 21 days they produce wax from glands which are on the underside of their abdomen; with this wax they build the comb in its beautiful shape and arrays.

During the third week they make short flights outside the comb. The older bees bring them nectar from flowers which they store in the comb as honey. They also act as guards or fan with their wings to create a ventilation current of air through the hive. For the remaining three weeks of their life they collect water, nectar and pollen. The pollen from flowers is removed from the hairy body by the brush on the hind leg and transferred to the pollen basket (diagram 96) of the opposite hind leg for carriage.



The worker bee
tongue fully extended and one wing removed
Diagram 96

LIFE CYCLE

The queen lays eggs into different cells according to whether they will develop into workers, drones or virgin queens. All eggs take about 3 days to hatch into the larva stage.

All the larvae consist of the head and 13 segments. They are fed on a milky white jelly which is secreted by the salivary glands of the nurse bees. The queen larvae continue to receive the royal jelly until they develop into the pupa stage. All larvae receive a diet of honey and digested pollen in addition.

Feeding of all larvae ceases when the cells are sealed on the 9th day after egg-laying. Development takes place and the larvae change pupae. The queen pupae are ready to emerge on the 16th day whereas the worker takes 21 days and the drone 24 days.

When the hive becomes overcrowded the queen departs with many of the workers before the virgins emerge from their cells. The first virgin emerges and generally kills all other virgins with her sting. About two weeks after the queen had departed, the virgin queen goes on a mating flight with a drone and returns to become the new queen of the colony. The cycle thus continues.

THE BIRDS

Birds are unique in the animal kingdom because they are the only ones which possess feathers, and are therefore ideally suited to their aerial environment. They have a constant body temperature such as the human beings, a well developed brain, and they show a remarkable degree of parental care for their young ones.

The body of a bird consists of the head, neck, trunk and tail. They have four jointed toes on each foot, each ending in a claw (diagram 97). Usually three toes point forward and one turns backwards which enables them to get a firm grip of twigs and smaller animals they catch. Some water-living (aquatic) birds like the duck have webbed feet. The small down feathers keep the body warm and the long ones in the wings and tail help the bird to fly. The old and faded feathers fall out at least once a year in all birds and bright ones grow to take their place. When the birds wear their brightest feathers and sing their sweetest songs we know spring is here.

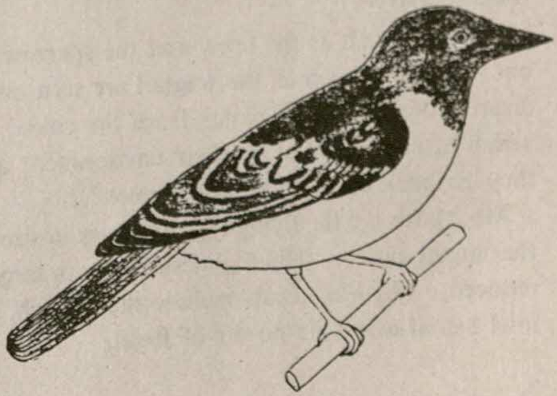


Diagram 97

NEST BUILDING

Spring is the mating time. The site for making their nest is first chosen; this must be close to food and away from enemies. Some make nests on the ground, others near streams and still others in shrubs and on trees. When the site is chosen, the material for nest is next collected. Twigs, leaves, grass and various odds and ends are collected and carefully woven together to form the cosy little nursery in which to lay the eggs and rear the young. Each type of bird builds its own kind of nest and lays its own type of eggs. When the eggs hatch, parents spend all their time looking for food and carrying it to the wide open mouths of the nestlings.

BEAKS AND FEEDING

The beaks of birds indicate something about the nature of their food. Those with long and thin beaks eat soft food such as worms and fleshy fruits. Short and strong beaks, such as of the sparrow, are suited for picking up crumbs and seeds. The woodpecker has a long and strong beak which it uses for picking insects from the bark of trees. The duck with its spoon-shaped bill scoops the mud from ponds and strains out small creatures for food. The parrot uses its strong hooked beaks for cracking nuts and for climbing. The owl, eagle and other birds of prey use their hooked beaks for tearing flesh from animals.

Birds have no teeth and cannot chew their food. The food is ground inside the body.

The head of birds is joined to the body by a long and flexible neck which enables them to turn right around and look behind them. Their eyes placed on the sides of the head are in the best position to give them a wide vision. They possess a keen sense of hearing but the sense of smell is not well developed.

MIGRATION

Many birds such as the crow and the sparrow may be found throughout the year but some birds such as the wagtail are seen only in the winter. These birds come down in winter to the plains from the colder northern regions in search of food which is not sufficient in their environment at that time. Once summer comes, they go back to their natural homes.

Most birds are the flying type and vary in size from the smallest humming birds to the largest eagles. The flightless birds are large and have long legs; their wings are reduced. Flightless birds include the ostrich, kiwi and penguins. The domestic fowl has also lost its power of flight.

PROBLEMS

1. **Why is the housefly considered to be a pest? At what stage in the life history of a housefly is it easiest to destroy it? Give two methods commonly used for the destruction of adult houseflies.**
2. **Why do earthworms hide during the day? In what way are they useful to man?**

3. People who breed honey bees often arrange to move their hives to fruit orchards in early summer. How does this practice benefit the bees as well as the fruit crop? In what other ways are the bees useful to man?

4. The diagram 98 is the sketch of a bee taken from an advertisement in a woman's magazine. List five features in which the sketch is inaccurate or incomplete.

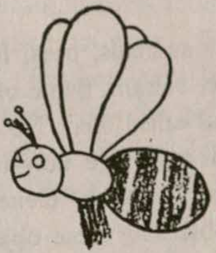


Diagram 98

5. What is meant by metamorphosis? Give the example of the housefly or the honey bee to explain the various stages of development during its metamorphosis.

15

Interdependence in Nature

It is easy to say that animals such as snails, bees, houseflies, earthworms and birds, and plants such as the mango tree, balsam, flame of the forest, cactus, etc. are living. They all possess something special called life. No one can doubt that rocks, motor cars, clouds and crystals of salt or sugar are non-living. How does one distinguish between what is living and what is non-living? Generally, all living organisms possess some similar characteristics; by observing these objects one can say that they possess life.

MOVEMENT OR LOCOMOTION

One of the easist ways to distinguish living objects is to find out whether they can move or not. Almost all animals move their whole body about when they go in search of food. When you hit a mosquito or a housefly, it movement stops; it is dead.

Rivers flow, aeroplanes fly in the sky and a cricket ball is in motion when released by a bowler towards the batsman. In these cases the energy for locomotion is provided from outside sources. A dam could be built to stop the flow of a river; there is a man in command of an aeroplane and it flies on fuel provided by us. Animals, on the other hand, move out of their own will.

Plants are almost always fixed in one place to the soil. They are surrounded by their food; hence, their obvious movements are restricted to organs such as stem tips, leaves and flowers. Have you noticed the blossoming of a bud into a flower? Some of them blossom within minutes.

GROWTH

All living organisms show growth. From small size they become big, and some change in form completely from a new born to the adult. A tiny seed can grow into a huge tree; a small egg can be the beginning of a huge bird.

Growth in animals may be discontinuous in the early stages, *e.g.* in the honey bee and housefly, but in the adult stage the growth is continuous. Growth in plants takes place continuously throughout their life time; it takes place both in length and girth. The growth is generally more in spring and less in the cold winter.

Plants grow quickly and indefinitely in most cases but animals grow only to a certain maximum size. The growth of animals is regular but in plants it is irregular.

An insect can have only three pairs of legs but a mango tree can have any number of branches.

FEEDING

Living beings, like machines, need energy to move and the source of this energy is the food we eat. A living being, in addition, uses the food for another important function *i.e.*, for growth and repair of old, worn out parts. For each animal its food and the method of obtaining it may vary. The bee seeks for nectar in flowers, the spider traps small insects in its web, the snail visits the garden for leaves and the vultures pry on dead bodies. Most green plants manufacture their own food from carbon dioxide, water and other chemicals; they spread their leaves wide to receive the light from the sun.

EXCRETION

The carbon dioxide and water vapour are waste products during our day to day activities. Other waste materials which contain nitrogen, etc. are got rid of from the body by a process called excretion. The getting rid of such unwanted substances is not very obvious in plants as it is in animals.

REPRODUCTION

The most remarkable feature of living organisms is to be able to produce more of its own kind. A living being grows to become an adult, and dies in old age or due to other factors; adults reproduce to perpetuate life.

Each tree produces many fruits, and each fruit may contain many seeds, but only a few receive the right conditions of soil, water, air and energy to germinate and grow; the others perish. Many animals produce only a small number of eggs or young ones, but look after them with great care and ensure perpetuation of their kind. Thus, generally, larger the number of progeny, lesser is the chance of their survival.

In most animals and plants, for reproduction to be achieved it is necessary that a male cell fuses with a female egg cell and fertilises it. In plants, which are rooted to the soil, this is helped by dispersal of the pollen by wind, water and insects. In animals the male and female generally come closer to enable the cells to combine.

SENSITIVITY

To be able to detect any change in its environment, and to respond to it, is a characteristic of the living.

Activity 1. Shine a bright beam of light on a person's eye; he quickly responds by contracting the pupil of the eye. He protects the delicate inner parts of the eye by allowing less light to enter.

Stroke gently with a match stick the tendril of a plant on the underside. You will notice that within a few minutes the tendril curls inwards. A dog barks at the sight of a stranger and a snail withdraws inside its shell on being disturbed. These are all examples of a specific response to a specific ***stimulus***. The change in our environment, which is the cause of a response, is called a stimulus.

CHARACTERISTICS OF THE LIVING

All the characteristics of a living being mentioned above have an inter-relationship which has significance to its survival and of its kind. This can be shown in the form of a diagram as given below:

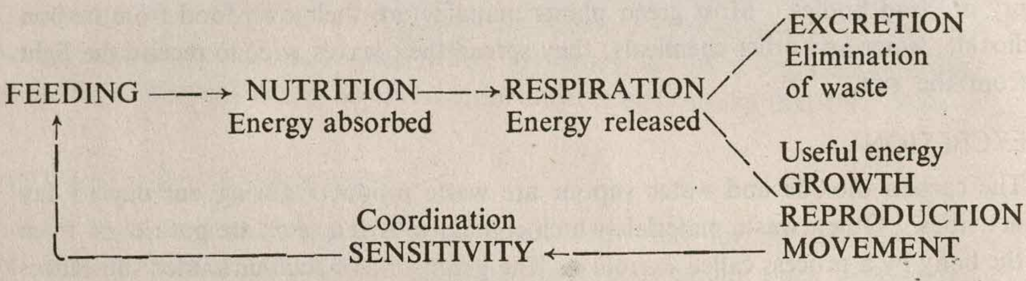


Diagram 99

LINK BETWEEN THE TWO WORLDS

All organisms, whether plant or animal, need food for their growth and survival. Green plants make (manufacture) their own food by the process called photosynthesis. In this process a plant takes water and certain chemicals from the soil and air, and energy from the sun, to produce ***proteins***, ***fats*** and ***carbohydrates*** which are used in their growth. Green plants are the only living organisms which convert energy and materials from the non-living world into the living world. Photosynthesis forms the link between the two worlds.

Animals however cannot make their own food; they have to eat it. This comes from plant or other animals.

THE FOOD CHAIN

Some animals only live on plants; these animals are called ***herbivorous***. Elephants and monkeys are herbivorous animals. Other animals eat animals; these are called ***carnivorous***. In any surroundings, the "eaters" and the "eaten" are linked together in a food relationship called the ***food chain***. For example, goats feed on grass and are in turn eaten by man. Worms feed on dead leaves and are eaten by small birds which are themselves eaten by owls and hawks.

A food chain on land can be shown as follows:

Plant $\xrightarrow{\text{(a)}}$ **Insects** $\xrightarrow{\text{(b)}}$ **Frog** $\xrightarrow{\text{(c)}}$ **Snake** $\xrightarrow{\text{(d)}}$ **Hawk**

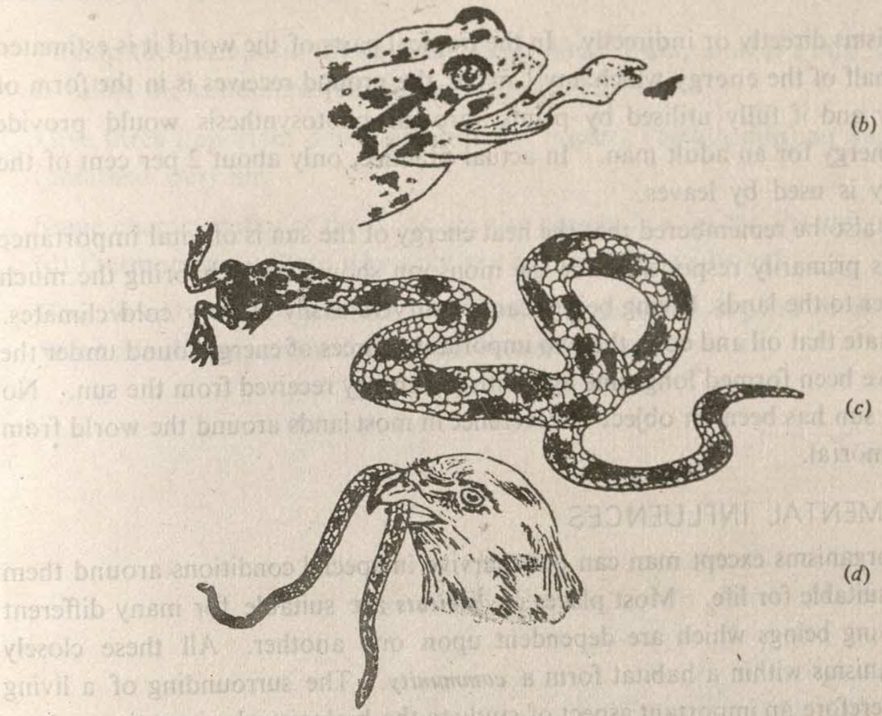


Diagram 100

Part of this food chain is shown in the diagram 100.

Another example involving life in the sea can be shown as follows:

Plankton in sea ——→ **Very Small** fish ——→ **Larger** fish ——→ **Very large** fish ——→ **Man**

Thus, a food chain invariably starts from plants which manufacture their own food, but many types of animals take part in this "game of life". Plants are called the ***primary producers*** because the food they produce supports the food requirements of the entire community. This is responsible for an inter-dependence between various forms of life. The largest ***predator*** at the end of the chain is as dependent on the plant as is the first animal in the food chain.

However, the process does not stop with the last predator. While it is not eaten by any larger animal, it does supply food to other smaller animals; when it dies it may be eaten by vulture, or consumed by fly larvae, bacteria, etc. The carbon dioxide and water are then returned to the atmosphere, and chemicals to the soil. The cycle is complete.

ENERGY FROM THE SUN

As can be seen from our study of the living world, the energy for their existence comes from the sun and is initially captured by green plants, and then transferred to other organisms directly or indirectly. In the tropical parts of the world it is estimated that about half of the energy which any 1 m^2 of the ground receives is in the form of light energy and if fully utilised by plants through photosynthesis would provide sufficient energy for an adult man. In actual practice, only about 2 per cent of the light energy is used by leaves.

It should also be remembered that the heat energy of the sun is of vital importance to us. It is primarily responsible for the monsoon showers which bring the much needed water to the lands. Living beings cannot survive easily in very cold climates. Scientists state that oil and coal, the two important sources of energy found under the ground, have been formed long time ago with the energy received from the sun. No wonder the sun has been an object of reverence in most lands around the world from time immemorial.

ENVIRONMENTAL INFLUENCES

All living organisms except man can only survive in special conditions around them which are suitable for life. Most places or ***habitats*** are suitable for many different types of living beings which are dependent upon one another. All these closely linked organisms within a habitat form a ***community***. The surrounding of a living group is therefore an important aspect of study to the biologist who investigates how the group obtains food, water, shelter, etc. This branch of science is called ***ecology***.

The conditions of life prevailing in a habitat are together termed the ***environment***. The various physical factors in an environment affecting life or living beings are light, temperature, humidity, soil structure, altitude, etc. The environment affects the organisms and they in turn affect the environment. The interdependence in nature is therefore very great.

PROBLEMS

1. What is meant by the statement: "the only independent organisms are the green plants."
2. Name two important gases found in the atmosphere. How do (a) plants, and (*b*) animals tend to change their proportion? Why does their proportion not change substantially over long periods of time?
3. If the balance of nature is disturbed by removing a link in a food chain, serious consequences may result. Describe an example of this happening due to the action of man.

4. Taking the example of (a) an earthworm, (b) an insect, and (c) a bird, state how it fulfils the conditions (characteristics) of life.
5. Give three important differences between inspired (breathed in) air and expired (breathed out) air.
6. Some characteristics of the living are also present in a (a) car, (b) train (c) cloud, (d) thermometer. State why they are not regarded as living?
7. How would you tell whether a particular organism is a plant or an animal? What are the important differences between them?

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